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Hill Air Force Base, Utah

Final

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision

SEPTEMBER 2015

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14. ABSTRACT
This Record of Decision presents the selected remedies for Operable Unit 10 – Site SS109 (Zone 1200) at Hill Air Force Base, Utah, under Contract No. FA8903-09-D-8560, Task Order 0006. The contaminants of concern associated with the Installation Restoration Program site addressed in this document include trichloroethene (TCE), tetrachloroethene (PCE), cis-1,2-dichloroethene (DCE), and trans-1,2-DCE in groundwater and TCE and PCE for on-Base soil gas. The U.S. Air Force evaluated remedial alternatives and selected enhanced bioremediation, monitored natural attenuation (MNA), and institutional controls (ICs) for the shallow TCE and PCE plumes, and MNA and ICs for the deep TCE plume.

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FINAL

Hill Air Force Base, Utah
Performance-Based Remediation

Operable Unit 10
Site SS109 (Zone 1200)
Record of Decision

Contract No: FA8903-09-D-8560
Task Order 0006

Prepared for:
Air Force Civil Engineer Center
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Acronyms and Abbreviations

δ	Delta
µg/L	Microgram(s) per liter
$M	Millions of dollars
‰	Per mil
^{12}C	Carbon-12
^{13}C	Carbon-13
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below ground surface
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
COC	Contaminant of concern
COV	Coefficient of variation
CPT	Cone penetration testing
CSF	Cancer slope factor
CSIA	Compound-specific isotope analysis
CZOM	Environmental Operations Midwest Region Branch
DCA	Dichloroethane
DCE	Dichloroethene
DWRi	Division of Water Rights
EA	EA Engineering, Science, and Technology, Inc. (prior to 12 December 2014) or EA Engineering, Science, and Technology, Inc., PBC (12 December 2014 and thereafter)
EISB	Enhanced in situ bioremediation
ELCR	Excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
ERD	Enhanced reductive dechlorination
ESD	Explanation of Significant Differences
ft	Feet; foot
ft/day	Feet per day; foot per day
ft/ft	Feet per foot; foot per foot
FS	Feasibility study
GED	Groundwater extraction and direct discharge
gpm	Gallon(s) per minute

HC	Hydraulic containment
HI	Hazard index
HQ	Hazard quotient
IC	Institutional control
IFC	International Fire Code
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
JBSA	Joint Base San Antonio
kg	Kilogram(s)
LDR	Land disposal restriction
LUC	Land use control
MCL	Maximum Contaminant Level
mg/L	Milligram(s) per liter
MK	Mann-Kendall
MNA	Monitored natural attenuation
MW	Montgomery Watson
NA	Not applicable
NAPA	North Area Preliminary Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	Operation and maintenance
OU	Operable Unit
OWS	Oil-water separator
PCE	Tetrachloroethene
POTW	Publicly owned treatment works
PRB	Permeable reactive barrier
RA	Remedial Action
RAO	Remedial action objective
RA-O	Remedial action operation
RBSL	Risk-Based Screening Level
RCRA	Resource Conservation and Recovery Act of 1976
RD	Remedial Design
RfC	Reference concentration
RfD	Reference dose
RG	Remediation goal
RI	Remedial investigation
ROD	Record of Decision
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
SPCC	Spill prevention, control, and countermeasures
SVE	Soil vapor extraction
SWPPP	Stormwater Pollution Prevention Plan

TCA	Trichloroethane
TCE	Trichloroethene
TCLP	Toxicity characteristic leaching procedure
TLV-TWA	Threshold limit value - time weighted average
TMV	Toxicity, mobility, or volume
UAC	Utah Administrative Code
UDEQ	Utah Department of Environmental Quality
UPDES	Utah Pollutant Discharge Elimination System
URF	Unit risk factor
USAF	U.S. Air Force
USC	United States Code
UST	Underground storage tank
UTM	Universal Transverse Mercator
VC	Vinyl chloride
VOC	Volatile organic compound
VRS	Vapor removal system

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1.0 Declaration

1.1 Site Name and Location

Facility Name: Hill Air Force Base.
Site Location: Davis County, Utah.
CERCLIS ID Number: UT0571724350.
Operable Unit/Site: Operable Unit 10 – Site SS109 (Zone 1200).

1.2 Statement of Basis and Purpose

This decision document or Record of Decision (ROD) presents the selected remedy for Operable Unit (OU) 10 at Hill Air Force Base (AFB), in Davis County, Utah. OU 10 is also identified as Site SS109 (Zone 1200) by the U.S. Air Force (USAF) Installation Restoration Program (IRP). OU 10 is one of 15 OUs in the IRP at Hill AFB. The selected remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record for this site.

The USAF is managing remediation of contamination at OU 10 in accordance with CERCLA as required by the Defense Environmental Restoration Program. Because Hill AFB is on the National Priorities List, and pursuant to CERCLA, the U.S. Environment Protection Agency (EPA) Region 8, the Utah Department of Environment Quality (UDEQ), and the USAF entered into a Federal Facility Agreement in April 1991. The purpose of the agreement was to establish a framework and schedule for developing, implementing, and monitoring appropriate remedial actions to address contamination at Hill AFB. The IRP is responsible for ensuring that appropriate CERCLA response alternatives are developed and implemented as necessary to protect public health, welfare, and the environment.

This ROD is issued by the USAF, which is the lead agency for cleanup actions at Hill AFB, and by EPA, which is the lead regulatory agency for CERCLA response actions at Hill AFB. This document was compiled and evaluated by the Air Force Civil Engineer Center/Environmental Operations Midwest Region Branch (AFCEC/CZOM). The USAF signatory for this document will be the 75th Air Base Wing Commander at Hill AFB. Under CERCLA Section 120(e)(4)(A) and the NCP, the USAF and EPA jointly select the remedy.

The State of Utah concurs with the selected remedy.

1.3 Assessment of Site

OU 10 – Site SS109 (Zone 1200) is located in the western portion of Hill AFB. Contaminants of concern (COCs) in groundwater at OU 10 include trichloroethene (TCE), tetrachloroethene (PCE), cis-1,2-dichloroethene (DCE), and trans-1,2-DCE, which exceed EPA Maximum Contaminant Levels (MCLs) in drinking water (the MCLs are 0.005 milligram(s) per liter [mg/L], 0.005 mg/L, 0.07 mg/L, and 0.1 mg/L, respectively).

OU 10 contains three groundwater plumes—the PCE Plume, Shallow TCE Plume, and Deep TCE Plume. The Deep TCE Plume also contains cis-1,2 DCE and trans-1,2-DCE above their EPA MCLs. No contaminants were detected in soil above EPA residential direct exposure Regional Screening Levels (RSLs) during the remedial investigation (RI) because the known contaminated soil had been removed during an earlier removal action (CH2M HILL 2009a). However, concentrations of TCE and PCE in on-Base soil gas exceed risk-based screening levels for potential future exposure pathways.

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment.

1.4 Description of Selected Remedy

The selected remedy addresses contaminated groundwater of each specific OU 10 plume and includes the following components:

PCE Plume

- In situ treatment with enhanced reductive dechlorination (ERD) to treat the highest concentrations of PCE in groundwater near the historical source area and mid-plume
- Monitored natural attenuation (MNA) of PCE in groundwater outside of the in situ treatment zones
- Institutional controls (ICs) to prevent use of the groundwater and ensure new construction projects over the on-Base areas of soil gas exceeding remediation goals (RGs) take into account the potential for vapor intrusion risks until remedial action objectives (RAOs) are achieved.

Shallow TCE Plume

- In situ treatment with ERD to treat the highest concentrations of TCE in the groundwater plume
- MNA of TCE in groundwater outside of the in situ treatment zones
- ICs to prevent use of the groundwater and ensure new construction projects over the on-Base areas of soil gas exceeding RGs take into account the potential for vapor intrusion risks until RAOs are achieved.

Deep TCE Plume

- MNA of TCE, cis-1,2-DCE, and trans-1,2-DCE in groundwater
- ICs to prevent use of the groundwater until RAOs are achieved.

1.5 Statutory Determinations

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost effective, and uses permanent solutions and alternative treatment technologies to the maximum extent practicable. The selected remedies for the PCE Plume and the Shallow TCE Plume satisfy the statutory preference for treatment as principal elements of the remedies. The remedy for the Deep TCE Plume does not satisfy the preference for treatment. MNA is not an active treatment but relies on natural processes to effectively reduce contaminant concentrations. The MNA timeframe is similar to the other alternatives developed, but with lower costs.

Because this remedy will result in hazardous substances, pollutants, or contaminants, remaining onsite above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of the remedial action to verify that the remedy is, or will be, protective of human health and the environment.

1.6 Data Certification Checklist

The following information is included in the Decision Summary section of this ROD (Section 2):

- List of COCs and their respective concentrations (Section 2.5.1 and Appendix A)
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the Baseline Risk Assessment (BRA) and ROD (Sections 2.6.2 and 2.6.3)
- Baseline risk represented by COCs (Section 2.7)
- Cleanup levels established for COCs and the basis for these levels (Section 2.8)
- How source materials constituting principal threats will be addressed (Section 2.11)
- Key factor(s) that led to selecting the remedy (i.e., describes how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision) (Section 2.13)
- Estimated capital; annual operation and maintenance (O&M); and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Appendix B).

Additional information can be found in the Administrative Record file for OU 10 – Site SS109 (Zone 1200), available online at the U.S. AFCEC, Air Force Administrative Record, http://afcec.publicadmin-record.us.af.mil/.

1.7 Authorizing Signatures and Support Agency Acceptance of Remedy

The USAF and EPA jointly select the remedy. The State of Utah concurs with the selected remedy. Authorizing and support agency signatures are included on the following pages.

U.S. ENVIRONMENTAL PROTECTION AGENCY

9/23/15

Martin Hestmark
Assistant Regional Administrator
Office of Ecosystems Protection and Remediation
U.S. Environmental Protection Agency Region 8

Date

STATE OF UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY

Alan Matheson
Executive Director
State of Utah Department of Environmental Quality

Sept. 24, 2015
Date

U.S. AIR FORCE MATERIEL COMMAND
HILL AIR FORCE BASE, UTAH

D. Wade Lawrence

D. WADE LAWRENCE, Colonel, USAF
Vice Commander, 75th Air Base Wing

24 Sept 2015
Date

2.0 Decision Summary

The decision summary identifies the selected remedies, explains how these remedies fulfill statutory and regulatory requirements, and provides a substantive summary of the Administrative Record file that supports the remedy selection decision.

2.1 Site Description and History

Hill AFB is located in northern Utah, approximately 30 miles north of Salt Lake City and approximately 7 miles south of Ogden. Hill AFB occupies approximately 6,700 acres within portions of Davis and Weber counties. Hill AFB has been the site of military activities since 1920, including distribution of military equipment, aircraft rehabilitation and maintenance, and missile assembly. A variety of ongoing industrial operations support the missions of Hill AFB, including metal plating, degreasing, paint stripping, painting, sanding, and other operations associated with aircraft, missile, and vehicle repair and maintenance. These industrial operations have generated numerous spent chemicals and wastes, including chlorinated and non-chlorinated solvents and degreasers, petroleum hydrocarbons, acids, bases, metals, and other chemicals.

Operable Unit 10 – Site SS109 (Zone 1200) encompasses the 1200 Area along the western boundary of Hill AFB and extends off-Base into the cities of Clearfield and Sunset (Figure 2-1). Industrial activities at the 1200 Area began in the early 1940s with the construction of inert material and combat equipment warehouses for the Ogden Arsenal, though little documentation exists as to the type of materials stored in these warehouses. Various operations were performed in the 1200 Area, such as cleaning, processing, and finishing of small arms, artillery, and optical equipment by vapor degreasing, alkali cleaning, sulfuric acid pickling, solvent cleaning, sand tumbling and blasting, acid rinsing, and spray painting. Chemicals used in these operations included chlorinated solvents (e.g., PCE and TCE), sulfuric acid pickling solution, acid rinse waters, mineral solvent, parco-lubrite solutions, light paraffin-based mineral oil, paints, lacquers, and thinners (Montgomery Watson [MW] 1995).

The suspected source of PCE contamination is located beneath the parking area west of Building 1274. This source was identified during a shallow soil and soil gas investigation conducted in 2008. Further investigation of this historical source of PCE has confirmed that it is no longer a continuing source of contamination. In 2002, a former oil-water separator (OWS) adjacent to Building 1244 was identified as a potential source of the shallow TCE groundwater contamination. The former OWS was removed in 2003 along with 4 cubic yards of contaminated soil located beneath the OWS (CH2M HILL 2009a). As for the Deep TCE Plume, hydraulic gradients, major ion data, and groundwater age dating provided evidence that the source of the Deep TCE Plume is most likely contaminated water from the Shallow TCE Plume. Figure 2-2 illustrates the estimated spatial extent of the OU 10 groundwater contamination that encompasses approximately 200 acres between the on- and off-Base areas near the West Gate of Hill AFB. Currently, most of the buildings in the 1200 Area are used for administration purposes, but the area also contains some buildings used as vehicle maintenance facilities and a heating plant.

As the lead agency, the USAF has conducted environmental restoration at OU 10 in accordance with CERCLA under the Defense Environmental Restoration Program, which was established by Section 211 of SARA. The EPA Region 8 is the lead regulatory agency for CERCLA response actions at Hill AFB; UDEQ is a support agency providing regulatory oversight. The Hill AFB Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Identification Number is UT0571724350 (EPA 2011). The USAF funds remediation.

2.1.1 History of CERCLA Enforcement Activities

As far back as the 1970s, compliance with applicable environmental regulations has been a priority in the operation of Hill AFB. Since 1984, the USAF has committed significant resources to assess and remediate environmental contamination identified at Hill AFB. CERCLA established a national program for responding to releases of hazardous substances into the environment. In anticipation of CERCLA, the Department of Defense developed the IRP to respond to releases of toxic or hazardous substances at Department of Defense facilities. Hill AFB was already engaged in the IRP when it was placed on the CERCLA National Priorities List in July 1987.

SARA, enacted in 1986, requires that federal facilities follow the NCP. In addition, the program requires greater involvement and oversight of the EPA for federal facility cleanups. The IRP follows these requirements. In response to SARA, the EPA developed the Guidance for Conducting RIs and Feasibility Studies (FSs) under CERCLA (EPA 1988). This document was used as guidance for preparing the RI and FS Reports for OU 10. A Guide for Preparing Superfund Proposed Plans, RODs, and Other Remedy Selection Decision Documents (EPA 1999a) was used as guidance in preparing the Proposed Plan for OU 10 (EA Engineering, Science, and Technology, Inc., PBC [EA] 2015) and this ROD.

2.1.2 Federal Facility Agreement

Since 1991, Hill AFB has conducted its environmental restoration activities under the Federal Facility Agreement that was signed in April 1991 by the USAF, EPA Region 8, and UDEQ. The purpose of the agreement was to establish a framework and schedule for developing, implementing, and monitoring appropriate remedial actions to address contamination at Hill AFB.

2.2 Highlights of Community Participation

The USAF followed a remedy selection process in accordance with the public participation requirements of CERCLA Sections 113(k)(2)(B)(i-iv) and 117. Additional requirements as outlined in the Hill AFB Environmental Restoration Community Relations Plan (Hill AFB 1997) were also fulfilled. The USAF generally meets quarterly with members of the Hill AFB Restoration Advisory Board, which consists of approximately 25 people representing the local communities; federal, state, county, and city governments; local sewer and water districts; civic, business, and environmental groups; the USAF, and other interested parties. Restoration Advisory Board meetings are advertised in local newspapers and open to the public. Community concerns are solicited and addressed prior to making a final proposal.

Upon completion of the RI/FS process, the USAF delivered the RI and FS documents to federal and state agencies and the Administrative Record, available online at the U.S. AFCEC, Air Force Administrative Record, http://afcec.publicadmin-record.us.af.mil/. The Administrative Record file is open to the public.

The Restoration Advisory Board was briefed on the proposed remedies for OU 10 on January 29, 2015. The Proposed Plan for OU 10 (EA 2015a) was presented to the public for comment in February 2015. The notice of availability of the Proposed Plan was published in the Ogden Standard Examiner on February 13, 2015. Written comments and attendance at the public meeting were encouraged. In addition, copies of the Proposed Plan were distributed to members of the city councils of Sunset and Clearfield prior to the start of the public comment period. The public comment period ran from 14 February to 15 March 2015. An open house format public meeting was held on 5 March 2015 at the Clearfield City Office. Public comments on the Proposed Plan for OU 10 are discussed in the Responsiveness Summary in Section 3 of this ROD.

2.3 Scope and Role of Operable Unit or Response Action

As with many large sites, environmental problems at Hill AFB are complex. As a result, the USAF, with approval from EPA Region 8 and concurrence from the UDEQ, has organized the environmental restoration work at Hill AFB into 15 OUs (Figure 2-1). The organization of OUs has been based upon geography, hydrogeology, and type of contaminated media. OUs 1 through 8, 12, and 13 have signed RODs or interim action agreements. Consequently, remedial actions are operational at 10 of Hill AFB's 15 OUs. This ROD addresses groundwater and soil gas contamination at OU 10 – Site SS109 (Zone 1200). Contaminants in indoor air within on-Base and off-Base buildings are addressed as part of OU 15.

The USAF has already initiated some remedial response actions at OU 10; specifically, removal of contaminated soil during the RI phase, a treatability study of in situ chemical oxidation and enhanced in situ bioremediation (through ERD) (CH2M HILL 2009a and 2009b) and a phytoremediation treatability study (Table 2-1). An additional treatability study is being performed on-Base at OU 10 to evaluate possible substrates and dosing scenarios for ERD. The selected remedies presented in this ROD for OU 10 incorporate or build upon these prior response actions.

2.4 Site Characteristics

2.4.1 Location and Climate

OU 10 – Site SS109 (Zone 1200) is located along the western boundary of Hill AFB in Davis County, Utah (Figure 2-1). The climate of Hill AFB is temperate and semiarid.

2.4.2 Geology

Sediments underlying OU 10 were deposited as transgressive and regressive sequences in Lake Bonneville and coincided with the deposition of the Paleo-Weber River Delta. The sediments include: coarser-grained fluvial and wave-influenced sand and gravel deposited on the floodplain and delta front; finer-grained sand and silt deposited as delta front and delta margin deposits (e.g., sheet sands); and interbedded sand, silt, and clay grading into fine-grained lacustrine silt and clay deposited on the pro-delta. The resultant stratigraphic architecture is composed of sand and silty sand deposits separated by silt, silty clay, and clay. Underlying the project area, the entire assemblage of sediment has been divided into three fundamental units: (1) sand; (2) silt and clay; and (3) interbedded sand, silt, and clay.

2.4.3 Hydrogeology

Three principal aquifers underlie the project area. From the surface, the aquifers are (1) an unnamed shallow aquifer system, (2) the Sunset Aquifer, and (3) the Delta Aquifer. Figure 2-3 illustrates the relationship between the aquifers. Approximate aquifer depths illustrated in Figure 2-3 were provided by a geophysical log from Clearfield Well #1. See Figure 2-2 for the Clearfield Well #1 location. The shallow aquifer system underlying OU 10 consists of two semi-independent water-bearing units, referred to as the Upper and Lower Zones (Figure 2-3). These zones are separated by an aquitard composed of silt and clay and are characterized by distinct groundwater flow directions (Figure 2-4).

The shallow aquifer system is separated from the Sunset Aquifer by a laterally extensive, low-permeability confining unit composed of stiff laminated silt and clay. The Sunset Aquifer is located approximately 450 to 540 feet (ft) below ground surface (bgs) and the Delta Aquifer is located approximately 650 to 1,000 ft bgs of the OU 10 area (CH2M HILL 2009a). The Delta Aquifer is classified as Class 1A groundwater and is the primary source of drinking water in the area. The Sunset Aquifer, although not used in the immediate area, is considered a secondary source of drinking water (CH2M HILL 2009a; Utah Division of Water Rights [DWRi] 1995).

Groundwater contamination at OU 10 is isolated within the shallow aquifer system. Current site data indicate contamination has not migrated to the Sunset or Delta Aquifers. The shallow aquifer system is not a source of drinking water in the area. Uncontaminated groundwater of the shallow aquifer would be classified under State of Utah rules as "Class II – Drinking Water Quality Groundwater," based upon background total dissolved solids concentrations that range from generally greater than 500 milligrams per liter (mg/L) to less than 3,000 mg/L. The USAF restricts access to the domestic use of and exposure to on-Base shallow groundwater within OU 10. The Utah DWRi, in coordination with the USAF, restricts access to contaminated groundwater in off-Base areas of OU 10.

2.4.3.1 Upper Zone

The Upper Zone consists of two hydrostratigraphic units—an unconfined aquifer and an underlying aquitard (Figure 2-4). The aquifer unit is primarily composed of fine to medium sand deposits. The aquitard is composed of low-permeability silt and clay with some interbedded sand.

Depth to shallow groundwater ranges from approximately 22 to 26 ft bgs on-Base to 8 to 15 ft bgs off-Base in the OU 10 area. Groundwater flows generally toward the southwest with an estimated average velocity of 0.5 ft per day. In the southwestern portion of the site, in a location where the aquitard separating the Upper and Lower Zones has been completely eroded, the Upper and Lower Zones are hydraulically connected. Horizontal hydraulic gradients become steeper toward the southwest within the Upper Zone; ranging from 0.01 foot per foot (ft/ft) in the on-Base northeast portion of the site to 0.05 ft/ft in the off-Base southwest portion of the site (CH2M HILL 2009a).

2.4.3.2 Lower Zone

The Lower Zone is also composed of a semi-confined aquifer unit and an aquitard (Figure 2-4). The aquifer consists of layers of sand and discontinuous lenses of silt, clay, and interbedded sand that vary in thickness and lateral extent. The aquitard is a low-permeability, laterally extensive, organic-rich, laminated silt and clay sequence that separates the entire shallow aquifer system from the underlying Sunset Aquifer and deeper Delta Aquifer.

Depth to groundwater within the Lower Zone ranges between approximately 50 and 185 ft bgs. The Lower Zone is confined in the southeastern corner and the western portions of the site but is unconfined in the northeastern and central portions of the site. Groundwater within the Lower Zone flows toward the northwest. The hydraulic gradient is relatively steep in the eastern portion of the site (0.10 ft/ft) and becomes flatter with thicker sands in the western portion of the site (0.01 ft/ft). Groundwater velocity estimates range from 1.9 ft per day in the eastern portion of OU 10 to 0.6 ft per day in the west (CH2M HILL 2009a).

2.4.4 Surface Water Hydrology

The Davis-Weber Canal is the only surface water body near OU 10 – Site SS109 (Zone 1200) and runs along the northern and western boundaries of Hill AFB (Figure 2-1). This canal is only in operation during the irrigation season from 15 April to 15 October. The canal passes over the Shallow TCE Plume, the PCE Plume, and the Southern and Northern Lobes of the Deep TCE Plume (Figure 2-2).

A large portion of OU 10 surface area is occupied by impervious surfaces (e.g., parking lots, roads, driveways, etc.). On-Base stormwater from these surfaces either enters the on-Base stormwater drainage system or infiltrates pervious surfaces. Surface water near OU 10 is collected by a series of storm drains that run into a stormwater drainage system, which drains into Bamberger Pond (Pond 6) near the West Gate. Off-Base stormwater either enters Sunset or Clearfield City stormwater drainage systems or infiltrates pervious surfaces.

2.4.5 Ecology

Animal species that may be present in the OU 10 area include reptiles, birds, and mammals, ranging from small rodents to medium-sized predators. According to the Hill AFB Integrated Natural Resources Management Plan (Select Engineering Services 2011), there are no known federal- or state-listed threatened or endangered animal or plant species residing at Hill AFB.

2.5 Investigative History

Investigations in the area defined as OU 10 – Site SS109 (Zone 1200) began in 1995 with the OU 9 North Area Preliminary Assessment (NAPA) (MW 1995). Table 2-1 provides background information and summarizes the series of investigations that led to this ROD and describes the CERCLA response actions undertaken at OU 10. The majority of the investigative activities occurred during the OU 10 RI. The following text provides details regarding the RI that took place between the North Area Site Inspection in 2000 (MW 2000) and the completion of the OU 10 RI Report in 2009 (CH2M HILL 2009a).

2001–2002. The objectives of the 2001 RI field investigations included determining the nature and extent of the groundwater contamination identified during the OU 9 North Area Site Inspection (MW 2000), gathering sufficient information to support human health and environmental risk-management decisions, and providing sufficient data to evaluate and support the development of potential remedial alternatives.

Investigation methods used during the RI included cone penetration testing (CPT), borehole drilling and monitoring well installation, soil/groundwater sampling, aquifer testing, aquifer age dating, soil gas and indoor air sampling, groundwater elevation measurements, and geophysical investigation. A summary of the exploration points installed or sampled throughout the history of the OU 10 investigation through 2009 is presented in Table 2-1 of the OU 10 RI Report (CH2M HILL 2009a).

By the end of 2002, the Shallow TCE Plume was found to extend approximately 3,000 ft beyond the Base boundary into Clearfield City, and the former OWS was identified as a potential source of TCE contamination. OUs 9, 10, and 11 were redefined so that areas with similar groundwater contamination and remedial objectives were grouped as distinct units. OU 10 was reorganized to address groundwater and soil contamination beneath the 1200 Area and the affected off-Base areas.

2003–2004. The scope of investigations expanded in 2003 and 2004, when contamination was detected in the Lower Zone (the Deep TCE Plume) while defining the vertical extent of the Shallow TCE Plume. In August 2003, the OWS that was identified as a potential TCE source was removed, and soil and groundwater samples were collected with a Geoprobe® near its former location. Investigation also continued at the former OWS, where additional soil samples were collected.

2005–2006. Shallow TCE Plume investigations in 2005 focused on defining the downgradient plume boundaries, or the "toe" of the plume, and additional delineation of the Deep TCE Plume.

A geochemical data collection project was conducted in 2005 to 2006 to help characterize the relationship between the Shallow and Deep TCE Plumes. The objectives of this effort included: (1) evaluating groundwater ages and velocities using dissolved noble gases (helium, neon, and argon) and tritium/helium-3 methods; (2) evaluating mixing of the Upper and Lower Zones and assessing groundwater flow directions and recharge zones using stable isotopes (hydrogen, oxygen, and carbon); (3) evaluating natural attenuation processes in the Deep TCE Plume through measurements of methane, ethane, ethene, and carbon dioxide; and (4) creating geochemical profiles of various parameters across contaminated zones to assess natural attenuation processes within the plumes.

2007. An in situ treatability study, aquifer testing, stable carbon compound-specific isotope analysis (CSIA), and microbial enzyme activity analysis were conducted in 2007. Numerous monitoring wells were installed to better define the boundaries of the PCE, Shallow TCE, and Deep TCE Plumes, and several monitoring wells were installed as part of the treatability study.

The treatability study was conducted to assist in the evaluation of possible remedial alternatives for the Shallow TCE Plume. Two remediation technologies, in situ chemical oxidation and ERD, were tested during the study. Data collected during the treatability study were used to evaluate the costs and benefits of each technology.

CPT was performed to investigate potential TCE and PCE contamination in the Upper Zone of the shallow aquifer system, upgradient of the former OWS. CPT was also performed in the Missile and Munitions Storage 1 Area (area upgradient from the 1200 Area) to investigate potential source areas for the Deep TCE Plume. Neither investigation found contamination.

A large-scale aquifer testing program was conducted in Spring 2007. The objectives of the testing were to (1) obtain hydraulic property estimates for the Lower Zone of the shallow aquifer system, (2) examine potential "leaky" confining conditions, and (3) evaluate the hydraulic connection between the Upper and Lower Zones near the farthest downgradient extent of the Shallow TCE Plume.

Groundwater samples were collected in 2007 to perform CSIA and to evaluate the potential for aerobic cometabolism of TCE in the Shallow TCE Plume.

In November 2007, shallow groundwater samples were collected at several locations overlying the Shallow TCE Plume to determine whether contamination was present near the water table. The sample results were used to support the baseline Human Health Risk Assessment in the OU 10 RI Report (CH2M HILL 2009a).

2008–2009. A geochemical investigation similar to the 2005 project was performed in 2008 to evaluate the relationship between the Shallow and Deep TCE Plumes. A microcosm study also was done to estimate the aerobic cometabolism degradation rate for the Shallow TCE Plume, and several samples were collected to determine the microbial communities present in the groundwater at OU 10. The objective of the microbial investigation was to identify microorganisms or microbial consortia that may play significant roles in the natural attenuation of chlorinated contaminants at OU 10.

In July 2008, a soil gas investigation was conducted with two primary objectives: (1) determine additional potential sources of PCE and TCE in the 1200 Area and (2) evaluate potential vapor intrusion risks in the on- and off-Base areas of OU 10. This investigation identified the historical source of PCE as a spill in a parking lot west of Building 1274. Based on the soil gas results, two additional investigations were performed. First, several soil samples were collected in the 1200 Area. The study included analyzing volatile organic compounds (VOCs) and radon in sub-slab and indoor air samples in seven buildings, performing building surveys, measuring outdoor air pressure, and monitoring the differences in pressure between sub-slab and indoor air. Indoor air for areas above OU 10 will generally be addressed in OU 15, the indoor air OU created to address all potential on- and off-Base indoor air exposure via vapor intrusion. However, individual sites or OUs are still responsible for addressing contaminated media (e.g., soil, soil gas, and groundwater) causing, or with the potential to cause, indoor air impacts.

In 2009, soil sampling for PCE was completed in the historical source area. CPT/HydroPunch sampling was performed to collect groundwater samples to define the downgradient extent of the PCE Plume. Two monitoring wells were installed near the toe of the PCE Plume to serve as sentinel wells. A second round of sub-slab and indoor air sampling was performed in the 1200 Area buildings to confirm the results of the initial (2008) sampling.

2.5.1 Nature and Extent of Contamination

The COCs at OU 10 include PCE, TCE, cis-1,2-DCE, and trans-1,2-DCE. The cis-1,2-DCE and trans-1,2-DCE are present in groundwater as degradation products of TCE. Figure 2-4 illustrates the conceptual model of groundwater contamination at OU 10.

2.5.1.1 Contaminant Sources

The suspected historical source of PCE contamination was a spill in the parking area west of Building 1274. The source of TCE contamination was a former OWS and related appurtenances at the north end of Building 1244. The former OWS was removed in 2003, and approximately 4 cubic yards of contaminated soils beneath the OWS were excavated.

Contaminant releases are assumed to have occurred between the early 1940s and 1959 when industrial activities were being performed in the 1200 Area. Currently, remaining concentrations of PCE and TCE in the soil gas, soil, and groundwater near the historical source areas are relatively low. These data, combined with the process and remediation history of the 1200 Area, do not indicate the presence of current active sources such as ongoing wastewater discharges or the storage or use of free-phase chemical products at OU 10.

2.5.1.2 Soil Contamination

The known extent of soil contamination at OU 10 is localized to the historical PCE and TCE source areas. No COCs have been detected in remaining soil above their respective EPA residential direct exposure RSLs. Following removal of the OWS and associated soil in 2003, the remaining soil contamination is not considered a significant continuing source of groundwater contamination. Multiple lines of evidence presented in the OU 10 FS Report (CH2M HILL 2009b) indicate that no ongoing soil contamination sources are contributing to the PCE Plume and Shallow TCE Plume. These lines of evidence include soil analytical data, trends in contaminant concentrations in groundwater near the source areas, and the site history.

2.5.1.3 Groundwater Contamination

Contamination has been identified in the Upper and Lower Zones of the shallow aquifer system (Figure 2-3). The COCs in the Upper Zone are PCE and TCE, referred to as the PCE Plume and the Shallow TCE Plume, respectively. In two known locations, contaminated groundwater from the Shallow TCE Plume has migrated through leaky portions of the aquitard into the Lower Zone (Figure 2-4). This contamination is referred to as the Deep TCE Plume. Based on the available data, groundwater contamination at OU 10 is confined to the shallow aquifer system and has not migrated into the underlying Sunset and Delta Aquifers. The groundwater contamination extent is shown in map view in Figure 2-2.

PCE Plume. Changes in the PCE Plume from 2012 to 2013 show that the PCE Plume has split into two lobes (on- and off-Base), approximately 3,100 ft long in total length, extending southwest from the 1200 Area into Clearfield (Appendix A and Figure 2-2). The plume is relatively narrow—only about 220 ft across at its widest point. Vertically, the PCE Plume is located near the water table (which is encountered at 8 to 25 ft bgs) and is approximately 20 ft thick. The RI Report (CH2M HILL 2009a) estimated the volume of groundwater within the PCE Plume as approximately 33 million gallons and the PCE mass within the plume as approximately 10 pounds (lbs).

The highest historical PCE concentration detected in the Upper Zone at OU 10 (722 micrograms per liter [µg/L]) was measured at Monitoring Well U9-12-006 in 2001. The highest PCE concentration measured in Spring 2014 data was also at Monitoring Well U9-12-006, but the concentration had decreased to 90 µg/L.

Table A-3 of Appendix A contains the following details for each PCE Plume groundwater monitoring well: the total number of sampling events; minimum, maximum, mean, and median PCE concentrations; the latest PCE result and sample date; and the plume stability trend.

Shallow TCE Plume. The Shallow TCE Plume (in the Upper Zone), present between 8 and 100 ft bgs, is located slightly south of the PCE Plume, and is located at greater depths on-Base. Off-Base, however, the Upper Zone becomes relatively thin, and portions of the Shallow TCE and PCE Plumes commingle. The Shallow TCE Plume is 300 ft wide on-Base, but becomes up to 1,400 ft wide off-Base, and has migrated approximately 4,900 ft southwest from the source area (Figure 2-2). The RI Report (CH2M HILL 2009a) estimated the volume of groundwater within the Shallow TCE Plume as approximately 270 million gallons and the TCE mass within the plume as approximately 206 lbs. TCE concentrations in wells within the main portion of the Shallow TCE Plume at the Base boundary have recently decreased below the MCL (5 µg/L); therefore, the Shallow TCE Plume is depicted as three lobes: an on-Base lobe, a small northern lobe at the Base boundary, and an off-Base lobe.

The highest historical TCE concentration in the Upper Zone was 489 µg/L, measured at off-Base Monitoring Well U10-020 in 2003. The TCE concentration in Monitoring Well U10-020 has since declined to 96 µg/L (Spring 2014 data), which is the current maximum TCE concentration in the shallow TCE Plume. The highest historical TCE concentration on-Base of 184 µg/L was measured at Monitoring Well U9-12-010 in June 2000. Concentrations have declined to 17 µg/L at this location according to data obtained during the Spring 2014 sampling round. Concentrations of cis-1,2-DCE and trans-1,2-DCE, which are anaerobic degradation products of TCE, have only been detected at trace concentrations below their MCLs (70 µg/L and 100 µg/L, respectively).

Table A-1 of Appendix A contains the following details for each Shallow TCE Plume groundwater monitoring well: the total number of sampling events; minimum, maximum, mean, and median TCE concentrations; the latest TCE result and sample date; and the plume stability trend.

Deep TCE Plume. In at least two locations, TCE-contaminated groundwater from the Shallow TCE Plume (Upper Zone) migrated through leaky portions of the aquitard into the Lower Zone, creating the Deep TCE Plume that consists of two different lobes (Northern and Southern Lobes) (Figure 2-2). In the Upper Zone, groundwater flows toward the southwest while in the Lower Zone groundwater flows to the northwest. Major ion data and groundwater age dating provided evidence that the source of the Deep TCE Plume is contaminated groundwater from the Shallow TCE Plume. Only TCE, cis-1,2-DCE, and trans-1,2-DCE have been present in the Lower Zone above their respective EPA-defined MCLs. The Northern Lobe is the largest of the two lobes and extends from on-Base in the 1200 Area to off-Base beneath Sunset City. Contamination is located between approximately 175 and 290 ft bgs and is approximately 2,800 ft long and 1,400 ft wide (at its widest point). Previously, a "Western Lobe" of the Deep TCE Plume had been defined around Monitoring Well U10-086A. However, based on updates to the plumes using 2013 data, the Western Lobe has now been redefined as part of the Northern Lobe. The Southern Lobe is located beneath the cities of Clearfield and Sunset, contains contamination between approximately 190 and 290 ft bgs and is approximately 1,400 ft long and 800 ft wide (at its widest point). The RI Report (CH2M HILL 2009a) estimated the volume of groundwater within the Deep TCE Plume as approximately 600 million gallons. The RI Report also estimated the mass of TCE, cis-1,2-DCE, and trans-1,2-DCE within the Lower Zone as 910 lbs, 220 lbs, and 70 lbs, respectively.

The highest historical TCE concentration in the Lower Zone was 750 µg/L, measured at Monitoring Well U10-089C in Fall 2008. Monitoring Well U10-089C is located near the downgradient toe of the deep plume northern lobe. The TCE concentration at Monitoring Well U10-089C has declined to 270 µg/L based on data obtained during the Spring 2014 sampling round, which is slightly less than the current maximum TCE concentration in the Lower Zone (300 µg/L at Monitoring Well U10-180C). The highest historical concentration of cis-1,2-DCE was 170 µg/L, measured at off-Base Monitoring Well U10-094A in 2010. The concentration of cis-1,2-DCE had declined to 110 µg/L at this well based on Spring 2014 data, which corresponds to the current maximum cis-1,2-DCE concentration in the Lower Zone. The highest historical concentration of trans-1,2-DCE was 200 µg/L, measured at off-Base Monitoring Well U10-080C in 2010. The maximum detected concentration of trans-1,2-DCE in the Lower Zone in Spring 2014 was 96 µg/L at Monitoring Well U10-094A. The TCE, cis-1,2-DCE, and trans-1,2-DCE contamination in the Lower Zone is located between approximately 175 and 290 ft bgs, and is constrained by the aquitard between the shallow aquifer and the Sunset Aquifer.

Table A-2 of Appendix A contains the following details for each Deep TCE Plume groundwater monitoring well: the total number of sampling events; minimum, maximum, mean, and median TCE concentrations; the latest TCE result and sample date; and the plume stability trend.

Table 2-2 presents the historical and current maximum on- and off-Base COC groundwater concentrations. Refer to the OU 10 RI Report (CH2M HILL 2009a), FS Report (CH2M HILL 2009b), and FS Supplement (EA 2014a) for additional details regarding the PCE and Shallow and Deep TCE Plumes.

2.5.1.4 On- and Off-Base Soil Gas Contamination

The highest soil gas concentrations of PCE and TCE were detected on-Base at Soil Gas Probe U10-540 and Sub-Slab Soil Gas Probe U10-9008, respectively. Soil gas contamination is derived from (1) volatilization of contaminants adsorbed to soil in the vadose zone and (2) volatilization of contaminants from the water table. The highest PCE and TCE soil gas concentrations are present in relatively small areas near the historical source areas (Figure 2-5).

Based on the extent of soil gas contamination, sub-slab soil gas and indoor air samples were collected in seven buildings in the 1200 Area to evaluate potential vapor intrusion. Concentrations of PCE and TCE detected inside the buildings were lower than the RSLs for the industrial exposure scenario. Several lines of evidence indicate a high degree of attenuation between soil gas and indoor air in the existing 1200 Area buildings (CH2M HILL 2009a). Table 2-3 presents the range of concentrations for PCE and TCE in on-Base soil gas. The OU 10 RI Report (CH2M HILL 2009a) presents additional details regarding the on-Base soil gas contamination.

Soil gas probes were installed in the off-Base residential area of OU 10 to investigate the potential for contaminants in the PCE and Shallow TCE Plumes to partition to soil gas. Over the Shallow TCE Plume, TCE was only detected in soil gas at trace concentrations at a few locations, suggesting that the Shallow TCE Plume has minimal to no impact on soil gas (Figure 2-6). Above the PCE Plume, PCE was detected in soil gas at slightly higher concentrations than TCE (Figure 2-6). The detected concentrations of PCE and TCE in off-Base soil gas were less than the soil gas RGs, which are based on a residential exposure scenario (Section 2.8). At the water table, concentrations of TCE and PCE in groundwater are typically not detected. In conclusion, the off-Base vapor intrusion pathways for the Shallow TCE Plume and PCE Plume are considered incomplete or insignificant.

2.5.2 Fate and Transport of Contaminants

The fate and transport of the contaminants at OU 10 – Site SS109 (Zone 1200) are controlled by source characteristics, physical and chemical properties of the contaminants, site physical characteristics (i.e., site hydrogeology), and subsurface geochemistry and microbiology. Because the known extent of contamination in the unsaturated zone is localized to the historical source areas, COC fate and transport evaluations focused on groundwater contamination. The conceptual site model of OU 10 was created as part of the OU 10 FS Report (CH2M HILL 2009b) (Figure 2-4).

An assessment of the fate and transport of PCE and TCE in the Upper Zone, and TCE in the Lower Zone, was performed as part of the FS. This assessment was accomplished using numerical modeling, as detailed in Appendix G of the OU 10 FS Report (CH2M HILL 2009b).

2.5.2.1 Contaminant Migration

Upper Zone (PCE and Shallow TCE Plume). Adsorption of TCE and PCE onto natural organic matter in soil limits contaminant velocities relative to the groundwater velocity. Whereas the estimated groundwater velocity is 0.5 foot per day (ft/day), the estimated dissolved TCE velocity is approximately 0.3 ft/day, and the estimated dissolved PCE velocity is approximately 0.2 ft/day (CH2M HILL 2009a).

Lower Zone (Deep TCE Plume). Greater organic carbon content in the Lower Zone limits contaminant transport more than in the Upper Zone. Whereas the estimated groundwater velocity in the western portion of Lower Zone is 0.6 ft/day, the estimated velocities for TCE, cis-1,2-DCE, and trans-1,2-DCE are approximately 0.2 ft/day, 0.4 ft/day, and 0.3 ft/day, respectively (CH2M HILL 2009a).

2.5.2.2 Plume Stability

Stability of the groundwater plumes at OU 10 was assessed based on trends of contaminant concentrations in monitoring locations and changes of dissolved contaminant mass over time using analytical data between 2006 and 2013. Statistical trend analysis was combined with spatial integration of the groundwater concentration data to provide an assessment of changes in point concentrations at individual monitoring locations, as well as the change in the total integrated mass within each plume.

The evaluation, which used the non-parametric Mann-Kendall test (Gilbert 1987), is presented in Appendix A and is summarized as follows:

PCE Plume. The majority of monitoring locations for the PCE Plume show decreasing or stable trends (Table A-3 and Figure A-5 of Appendix A). In the off-Base part of the plume, one monitoring well (U10-175) shows an increasing trend. However, PCE concentrations near the leading edge of the plume at Monitoring Well U10-142 do not show a statistically significant trend. Because there is no continuing PCE source and concentrations are relatively low, any plume expansion at the leading downgradient edge of the plume is expected to be transient and within the footprint of the Shallow TCE Plume. Further, planned treatment of the higher concentration areas in the on- and off-Base plume areas will reduce mass discharge to groundwater downgradient of the treatment zones to help limit potential future downgradient PCE Plume expansion. Additionally, as shown in Appendix A, Thiessen-polygon analysis for the PCE Plume demonstrates dissolved mass reduction of approximately 29 percent from 2006 to 2013.

Shallow TCE Plume. The majority of monitoring locations for the Shallow TCE Plume show decreasing or stable trends (Table A-1 and Figures A-1 and A-2 of Appendix A). For monitoring points exhibiting no trend at the 95 percent confidence level, concentrations are deemed stable if the coefficient of variation (COV) is equal to or less than 1. With the exception of one location west of the rail line, concentrations of TCE at monitoring locations outside the plume boundary have consistently been below the MCL of 5 μg/L. The dissolved mass of TCE in the Shallow TCE Plume has decreased approximately 25 percent since 2006. Data suggest that the Shallow TCE Plume is stable and likely receding.

Deep TCE Plume. The majority of monitoring locations for the Deep TCE Plume show decreasing or stable trends (Table A-2 and Figures A-3 and A-4 of Appendix A). For monitoring points exhibiting no trend at the 95 percent confidence level, concentrations are deemed stable if the COV is equal to or less than 1. Concentrations of TCE at monitoring locations outside the plume boundary have consistently been below 5 μg/L. The dissolved mass of TCE in the Deep TCE Plume appear stable. Overall, the core of the Deep TCE Plume appears to be contracting. Localized expansion may be occurring near groundwater Monitoring Well U10-086A (Figure A-3 of Appendix A), but with decreasing upgradient concentrations, any expansion is expected to be transient.

2.5.2.3 Natural Attenuation

Multiple lines of evidence indicate natural degradation of PCE and TCE within the groundwater plumes is occurring. The destructive mechanisms include reductive dechlorination and aerobic cometabolism. Table 2-4 presents the lines of evidence that support natural degradation and are discussed in greater detail in Section 5 of the OU 10 RI Report (CH2M HILL 2009a) and Section 1.4.3 of the OU 10 FS Report (CH2M HILL 2009b). This section summarizes the detailed discussion in the OU 10 RI and FS Reports.

Characterization and evaluation of natural attenuation was performed in accordance with the Office of Solid Waste and Emergency Response Directive 9200.4-17P: Use of MNA at Superfund, Resource Conservation and Recovery Act (RCRA) Corrective Action, and Underground Storage Tank (UST) Sites (EPA 1999b) and the Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (EPA 1998). The plumes were evaluated for stability as described previously to determine the suitability for MNA as a remedy. Following determination of plume stability, the "weight of evidence" for MNA was assessed by evaluating (1) contaminant concentration/mass trends, (2) geochemical conditions supporting inference of the degradation mechanism and degradation rates, and (3) field and microcosm data indicating the biological mechanism of degradation. Table 2-4 summarizes the assessment of natural attenuation and the remainder of this section highlights key results.

Total PCE and TCE masses have been stable or decreasing for each of the OU 10 groundwater plumes. Figure 2-7 shows the mass trends of each plume as estimated by Thiessen-polygon analysis (Appendix A). Results indicate an approximate 25 percent decrease in dissolved TCE mass within the Shallow TCE Plume and a 29 percent decrease in dissolved PCE mass since 2006, which supports the Level 1 line of evidence for natural attenuation (Table 2-4).

An evaluation of the geochemical parameters found secondary lines of evidence of biological degradation mechanisms. As shown in Table 2-4, average redox conditions have been observed as aerobic in the Upper Zone and anaerobic in the Lower Zone. The high standard deviations and ranges suggest considerable variability in redox conditions. A gradation to reducing conditions in the finer-grained base of the Upper Zone may contribute to the variability observed there. A dual-porosity system in which some aerobic conditions may exist in the mobile porosity and anaerobic conditions predominate in the immobile porosity may contribute to the variability observed in the Lower Zone (CH2M HILL 2009a). The geochemical conditions suggest a combination of biological degradation mechanisms, with aerobic processes dominating in the aquifer portion of the Upper Zone and the mobile porosities of the Lower Zone and anaerobic processes dominating in the basal aquitard of the Upper Zone and the immobile porosities of the Lower Zone.

CSIA of groundwater samples collected from the Deep TCE Plume indicate reductive dechlorination is occurring. Reductive dechlorinating microbes that use a chlorinated solvent as an electron acceptor selectively fractionate the lighter carbon-12 (^{12}C) from the heavier carbon-13 (^{13}C) during electron transfer. Consequently, reductive dechlorination results in a residual pool of parent product depleted in ^{12}C and enriched in ^{13}C, resulting in a "heavy" delta (δ) ^{13}C composition. Conversely, the daughter product becomes depleted with respect to ^{13}C and obtains a "light" $\delta^{13}C$ value relative to the parent product. Results of the CSIA for the OU 10 groundwater samples are consistent with carbon isotope fractionation during microbial degradation of TCE to DCE. This is further supported by the presence of cis-1,2-DCE and trans-1,2-DCE in the Lower Zone. Further, estimated half-lives from the CSIA data, ranging between 4 and 60 years, suggest rapid degradation in portions of the Lower Zone.

Field and microcosm investigations have given biological data consistent with the geochemical data. Given the average aerobic conditions of the Upper Zone, field and microcosm studies of aerobic cometabolism of TCE were performed for this zone. Groundwater samples from the Upper Zone contained enzymes used by microbes to aerobically cometabolize TCE (CH2M HILL 2009a). A bench-scale microcosm study of aerobic cometabolism also showed the presence of enzymes used for cometabolism of TCE coupled with reduction in TCE concentrations. Further, the microcosm study showed reductions in TCE concentrations at rates that compared reasonably well with rates estimated by other methods.

An investigation of microbes capable of reductive dechlorination was conducted for the Lower Zone because of the average geochemically reducing conditions and presence of reductive dechlorination daughter products (Section 2.5.1). The investigation indicated the presence of *Desulfuromonas* and *Dehalobacter* (Table 2-4). These microorganisms have been shown to be capable of reductively degrading TCE.

An additional potential attenuation mechanism likely contributing to TCE and PCE mass removal is rhizodegradation. The shallow depth of the PCE Plume in the off-Base portion of OU 10 and the presence of phreatophytes like poplar and cottonwood trees suggest that degradation of PCE in the rhizosphere (rhizodegradation), uptake, and transpiration of PCE is possible. A phytoremediation treatability pilot test was conducted at OU 10 from 2010 through 2011 to determine if hybrid poplar trees at two separate test plots would uptake and volatilize TCE and PCE in groundwater (Utah State University 2012). Tree core samples collected throughout the test indicated that uptake of TCE and PCE was occurring. Volatilization from tree trunks and leaves was also measured throughout the test. Leaf volatilization was determined to be an insignificant removal mechanism since little TCE and PCE was detected while measuring leaf volatilization. Trunk volatilization was observed more consistently than leaf volatilization. However, based on findings at other phytoremediation studies, leaf volatilization is expected to increase as the trees mature while the importance of the trunk volatilization route is expected to decrease as bark thickness increases (Klein 2011). Soil surface volatilization measurements collected at the test plots also indicated TCE and PCE soil volatilization was occurring, albeit at a minimal rate.

In summary, data collected indicate that each of the OU 10 groundwater plumes is naturally attenuating through various mechanisms, as observed in changes in the PCE and Shallow TCE Plume shapes over time and more recently between 2012 and 2013 (Appendix A and Figure 2-2). Dissolved masses are stable or declining, and the mechanisms of degradation interpreted from biological data are consistent with the redox conditions.

2.6 Current and Potential Future Land and Resource Uses

2.6.1 Institutional Controls and Land Use Controls

ICs have been implemented Basewide and in affected off-Base areas. These ICs consist of land use controls (LUCs) to restrict access to groundwater from the shallow aquifer system and the evaluation and potential mitigation of vapor intrusion risks for future on-Base construction. Through ICs and LUCs, the Utah DWRi (in off-Base areas) and the USAF (in on-Base areas) restrict new water rights and the drilling of wells within OU 10 – Site SS109 (Zone 1200) (Utah DWRi 1995). This groundwater restriction includes disallowing installation of any new groundwater supply wells within the area of shallow contaminated groundwater.

Off-Base, the Utah DWRi enforces the groundwater restrictions through a permitting process. People seeking to appropriate water (to access groundwater by constructing a well) must apply for a water right.

As specified in Section III, Point 7 of the Groundwater Management Plan for the Weber Delta Sub-Area of the East Shore Area, contaminated groundwater near Hill AFB is restricted, and “no new applications to appropriate water or change applications which propose to transfer water into these restricted areas will be granted” (Utah DWRi 1995). The ICs are registered through the State Engineer’s Office and Utah DWRi. The USAF sends the Utah DWRi a memorandum and map with updated groundwater contamination information annually. The USAF performs water right inspections as part of the Five-Year Review. These water rights inspections use the State’s database to confirm that new water rights have not been granted in the areas where groundwater exceeds MCLs. Groundwater use restrictions are to continue until RAOs are met, after which the State Engineer will consider allowing the construction of wells.

The USAF distributes a Restricted Areas Use Map to departments across the Base, updating and redistributing the map as necessary. In addition, the USAF reviews all completed Base Civil Engineer Work Order request forms (USAF Form 332) for construction activities proposed in these restricted areas. Annual IC audits including visual inspections are used to determine any IC violations. The USAF will notify the EPA and UDEQ if IC violations occur.

The areas of ICs at OU 10 are illustrated on Figures 2-5 and 2-8. Section 2.9.4.2 includes additional details about the implementation of ICs.

2.6.2 Land Use

Current on-Base land uses of OU 10 – Site SS109 (Zone 1200) include industrial, administrative, and military. The current adjacent land uses are primarily industrial, administrative, and military, with a few commercial sites to the southwest (i.e., credit union and fast food restaurant). The 1200 Area and the area southwest of OU 10, approximately 0.5 mile from the shallow on-Base plumes, is planned to become a non-military business park as part of the West Side Development Enhanced Use Lease project, according to the Hill AFB Comprehensive Plan. New development would change the land use near OU 10 from industrial to commercial. The industrial exposure scenarios of the OU 10 BRA would capture the land use change from industrial to commercial. According to the Hill AFB Comprehensive Plan, Hill AFB is expected to remain an active military installation for the foreseeable future. Therefore, the remaining adjacent on-Base land uses at OU 10 are reasonably anticipated to continue as industrial, administrative, and military indefinitely to support the mission of the facility. Should future land use differ from the reasonably anticipated land use, the USAF and EPA, in consultation with UDEQ, will reassess risks appropriate to future use.

Off-Base, the OU 10 plumes underlie an area at the border between Sunset City and Clearfield, which consists of Interstate-15, Main Street, and some businesses and residences. The land use of Main Street is commercial according to zoning maps published by the Sunset City Planning Commission in 2008. The off-Base land of Clearfield City that overlies the OU 10 plumes is primarily residential with some commercial along Main Street. In assessing risks, commercial land use is equivalent to industrial land use (EPA 1989). Future land use overlying OU 10 within the cities of Sunset and Clearfield is not expected to change but to remain residential and commercial.

2.6.3 Groundwater Uses

The aquifer beneath and near OU 10 – Site SS109 (Zone 1200) is the unnamed shallow aquifer, which consist of two saturated zones—Upper and Lower Zones (Figure 2-3)—as described in Section 2.4.3. Groundwater restrictions established by the Utah DWRi prohibit new wells in the shallow aquifer system in off-Base areas near Hill AFB, which includes the areas of groundwater impacted by contaminants at OU 10 (Utah DWRi 1995).

Currently, the groundwater in on-Base or off-Base areas that is impacted by OU 10 is not being used for any purpose; there are no authorized wells (public or private) that draw groundwater from the shallow aquifer that is impacted by OU 10 contamination. However, Utah law requires consideration of the shallow aquifer for future potable use. Based upon background total dissolved solids concentrations generally greater than 500 mg/L but less than 3,000 mg/L, the uncontaminated groundwater of the shallow aquifer would be "Class II—Drinking Water Quality Groundwater." Rule R317-6-4 ("Ground Water Class Protection Levels") of the UAC stipulates that "Class II ground water will be protected for use as drinking water or other similar beneficial use with conventional treatment before use." By these classifications and protection levels, the State of Utah considers the shallow aquifer to be of potentially beneficial use. Although the shallow aquifer is currently not used, the potentially beneficial use mandates risk assessment under future potable water use exposure scenarios. The contracting and stable plumes imply that the groundwater plumes will not affect the shallow zone downgradient of the current plume boundaries.

2.7 Summary of Site Risks

The risk assessment process summarizes potential human health and ecological risks and hazards under baseline conditions (i.e., assuming no remedial actions are taken and no risk management strategies [ICs] are in place) for current and hypothetical future exposure scenarios. It provides the basis for taking action and it identifies COCs. The risks to human and ecological receptors from potential exposure to contaminants in media at on- and off-Base areas of OU 10 were originally evaluated in the OU 10 RI Report (CH2M HILL 2009a).

Based on findings in the approved RI Report and Revised FS Report, the OU 10 contaminants (by media) discussed in this risk summary include:

- Groundwater used as hypothetical future tap water
  - PCE
  - TCE
  - cis-1,2-DCE
  - trans-1,2-DCE
  - vinyl chloride (VC)
- Soil gas as a potential source of future vapor intrusion
  - PCE
  - TCE

Indoor air monitoring in on-Base and off-Base areas of OU 10 has been conducted to assess potential migration of OU 10-related vapors to indoor air via the vapor intrusion pathway. Characterization and risk assessment related to current indoor air monitoring is performed under the OU 15 CERCLA activities and is not addressed further in this ROD.

Following finalization of the OU 10 RI Report, monitoring of groundwater contaminants continued at OU 10. The EPA revised toxicity factors for PCE and TCE in 2011 and 2014, respectively, and removed inhalation toxicity factors for cis-1,2-DCE in 2014. The EPA also recently revised other exposure parameters inherent in the risk assessment process, such as body weight, exposure durations, and tap water ingestion rates (EPA 2014a). Therefore, updated risk estimates were prepared for this ROD using recently collected site data, current toxicity values, and current exposure parameters.

The OU 10 RI Report (CH2M HILL 2009a) included an evaluation of ecological risks and concluded, "… there are no complete exposure pathways between contaminants and ecological receptors and, therefore, no potential for risk to ecological receptors. Therefore, no further action based on ecological receptors is warranted." Because there have been no changes in land use that would warrant revisiting these findings, and none are expected, ecological risks are not a factor in selecting remedies for the OU 10. Thus, the following summary focuses on human health risks only.

2.7.1 Updated Risk Estimates

Updated risk estimates were prepared using recent groundwater monitoring data and changes in EPA toxicity and exposure factors. Updated groundwater concentrations consist of the maximum detected concentrations of site-specific COCs from samples collected between January 2013 and March 2014 (EA 2013; EA 2014b). Table 2-5 summarizes groundwater COC concentrations used in the risk assessment update. Soil gas concentrations used in the risk assessment update consist of the maximum detected concentrations of site-specific COCs from samples collected between July 2008 and April 2009 (CH2M HILL 2009a). There are no more recent soil gas data; the highest detected PCE and TCE concentrations in soil gas are included in Table 2-5.

EPA's Integrated Risk Information System (IRIS) database was updated in 2011 for PCE and in 2012 for TCE. The updates included the following toxicological factors:

- Carcinogenic effects
  - Oral slope factors
  - Inhalation unit risk factors
- Non-carcinogenic effects
  - Oral reference doses
  - Inhalation reference concentrations.

In addition, EPA archived (removed from use) the inhalation reference concentration for trans-1,2-DCE due to inconsistencies in its derivation (EPA 2014a).

Table 2-6 summarizes current IRIS toxicity factors for the OU 10 COCs. EPA also updated exposure factors in 2014, and the relevant updated factors are shown in Table 2-7. Risk estimates were updated using forward risk calculations. Tables 2-8 and 2-9 summarize the applicable variables and equations, which are consistent with the most current risk assessment guidance documents (EPA 1989; EPA 2004; EPA 2009; EPA 2014a).

Table 2-10 summarizes the updated risk estimates, which are further distilled below and presented in comparison to the NCP-acceptable non-cancer hazard index (HI) (1) and cumulative ELCR range (10^{-6} to 10^{-4}). The summary below identifies "risk drivers" as those analytes contributing at least 10 percent of the total hazard or risk exceeding the NCP criteria.

- Groundwater as tap water
  - Analytes evaluated: PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC
  - HI = 100 (above NCP criterion)
  - Cumulative excess lifetime cancer risk (ELCR) = 7×10^{-4} (above NCP criterion)
    - Risk Driver: TCE
- Future hypothetical residents via vapor intrusion
  - Analytes evaluated: PCE and TCE
  - HI = 200 (above NCP criterion)
    - Cumulative ELCR = 9×10^{-4} (above NCP criterion)
    - Risk Driver: TCE.

Based on the results and analysis provided above, TCE is the primary risk driver for groundwater and soil gas. Contaminants exceeding Applicable or Relevant and Appropriate Requirements (ARARs) (specifically, MCLs in groundwater) include PCE, TCE, cis-1,2-DCE, and trans-1,2-DCE. The maximum detected concentration of VC (0.73 µg/L) does not exceed its MCL (2 µg/L), and the frequency of detection for VC is less than five percent. Based on this assessment, including VC as a COC is not warranted. Based on the risk assessment summary and ARAR evaluation (Section 2.8), the final COCs include:

- PCE, TCE, cis-1,2-DCE, and trans-1,2-DCE in groundwater
- PCE and TCE in soil gas.

2.7.2 Basis for Response Action

The BRA indicates that there are complete or partially complete pathways between chlorinated VOC contaminants in groundwater and both actual and reasonably anticipated future human receptors. The OU 10 RI Report (CH2M HILL 2009a) found that risks and hazards associated with direct or indirect exposure to contaminants in soil were insignificant. Remedial action for groundwater and on-Base soil gas at this site has been determined to be necessary because of (1) MCL exceedances for PCE, TCE, cis-1,2-DCE, and trans-1,2-DCE in groundwater during the period of 2013 to 2014 (Table 2-2); (2) contaminants in groundwater contributing significantly to hazards and risks above NCP criteria; and (3) concentrations of contaminants in on-Base soil gas (Table 2-10) contributing significantly to hazards and risks above NCP criteria. Concentrations of COCs requiring a response action for groundwater and soil gas are summarized in Tables 2-2 and 2-3, respectively. The extent of impacts to groundwater and soil gas is shown on Figure 2-2.

It is the current judgment of the USAF, EPA Region 8, and UDEQ that remedial action is necessary and that the selected remedy identified in this ROD is necessary to protect public human health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. Achieving MCLs (i.e., compliance with ARARs) was a main goal in assessing and selecting remedies, as described in Sections 2.9 through 2.13.

2.8 Remedial Action Objectives

To be protective of human health and the environment and address potential future risks identified in the BRA, and based on the current and reasonably anticipated future land use of Hill AFB and the cities of Clearfield and Sunset, as well as potential beneficial use of groundwater as described in Section 2.4.3, the RAOs for OU 10– Site SS109 (Zone 1200) include the following:

- **RAO 1:** Prevent direct human exposure to contaminated groundwater.

- **RAO 2:** Prevent unacceptable human health risks posed by potential future inhalation of contaminant vapors in on-Base indoor air.

- **RAO 3:** Prevent further horizontal and vertical plume migration.

- **RAO 4:** Restore groundwater to its expected beneficial use within a reasonable timeframe. Given the hydrogeologic setting and current available remedial technologies, restoration timeframes of 50 to 100 years are anticipated and considered reasonable.

RAO 2 was designed to address on-Base indoor air issues related to vapor intrusion. Since publication of the OU 10 FS, a new OU (OU 15) has been established to address impacts to indoor air. However, individual sites or OUs are still responsible for dealing with the contaminated media (e.g., soil, soil gas, and groundwater) causing, or with the potential to cause, indoor air impacts above regulatory targets.

RGs for groundwater at OU 10 are presented in Table 2-2. The RGs for the COCs in groundwater are based upon chemical-specific ARARs, EPA Safe Drinking Water Act MCLs, and the revised risk assessment presented in Section 2.7.

The RGs for soil gas are risk-based concentrations and are presented in Table 2-3. Derivation of the RGs for soil gas is presented in Table 2-11, which uses the lower of two target risk levels: an ELCR of 10^{-5} or a non-cancer hazard of 1. ELCR values within the 1×10^{-6} to 1×10^{-4} range involve a risk management decision that includes evaluating site-specific characteristics and exposure scenario factors to assess whether remedial action is warranted for protection of human health. The NCP preamble further clarifies this as follows (emphasis added):

> *Preliminary remediation goals for carcinogens are set at a 10^{-6} excess cancer risk as a point of departure, but <u>may be revised to a different risk level within the acceptable risk range based on the consideration of appropriate factors</u> including, but not limited to: exposure factors, uncertainty factors, and technical factors. Included under exposure factors are: the cumulative effect of multiple contaminants, the potential for human exposure from other pathways at the site, population sensitivities, potential impacts on environmental receptors, and cross-media impacts of alternatives. Factors related to uncertainty may include: the reliability of alternatives, the <u>weight of scientific evidence concerning exposures</u> and individual and cumulative health effects, and the reliability of exposure data. Technical factors may include: detection/quantification limits for contaminants, technical limitations to remediation, the ability to monitor and control movement of contaminants, and background levels of contaminants. The final selection of the appropriate risk level is made when the remedy is selected based on the balancing of criteria.*

Hill AFB has utilized Mitigation Action Levels based on a target ELCR of 1×10^{-5} in managing potential actions related to vapor intrusion as part of the Indoor Air Program (MWH 2004). An ELCR of 10^{-5} is $1/10^{th}$ of the maximum value within the NCP acceptable range. Numerous levels of conservatism are inherent in the risk calculations. Additionally, while soil gas RGs are for a future, hypothetical residential exposure scenario, the current land use is industrial. Based on the combination of these site-specific factors, an ELCR of 10^{-5} was used in the derivation of the soil gas RGs.

2.9 Description and Evaluation of Remedial Alternatives

This section provides a description of each alternative considered for remediation of the OU 10 Zone – Site SS109 (Zone 1200) groundwater plumes (PCE Plume, Shallow TCE Plume, and Deep TCE Plume). These alternatives are presented in detail in the OU 10 FS Report (CH2M HILL 2009b) and the OU 10 FS Supplement (EA 2014a). Various plume-specific remedial alternatives were developed to meet the RAOs presented in Section 2.8 and were evaluated against the nine NCP evaluation criteria (40 CFR 300). Elements common to the alternative descriptions are also summarized. The specific details of the remedial alternatives are intended only to serve as examples of available types of technology to allow calculation of order-of-magnitude cost estimates. Additional remedial process options that may achieve the same objectives may be evaluated during remedial design activities for OU 10.

2.9.1 PCE Plume Alternatives

2.9.1.1 PCE Alternative 1—No Action

Alternative 1 consists of taking no further action. This alternative serves as a baseline for evaluating alternatives and is required by the NCP.

2.9.1.2 PCE Alternative 2—MNA and ICs

Alternative 2 includes MNA, continued groundwater monitoring, and groundwater use restrictions. The RAOs would be met within 65 years.

2.9.1.3 PCE Alternative 3—Permeable Reactive Barrier, MNA, and ICs

Alternative 3 is designed to reduce PCE concentrations and prevent further migration of the plume by installing a 2.6-ft-wide trench filled with granular iron and sand to serve as a permeable reactive barrier (PRB). Natural attenuation upgradient of the trench should continue to reduce PCE concentrations over time. The RAOs would be met in approximately 50 years.

2.9.1.4 PCE Alternative 4—Groundwater Extraction and Discharge, MNA, and ICs

Alternative 4 consists of installing one groundwater extraction well with the objective of preventing on-Base groundwater contamination from migrating off-Base, thereby reducing the remedial timeframe. Extracted groundwater would be pretreated if any pretreatment limits would be exceeded before discharge to the sanitary sewer for treatment at the local publicly owned treatment works (POTW). The MNA component of this alternative consists of allowing portions of the plume downgradient of the extraction well to naturally attenuate. With an assumed extraction rate of 10 gallons per minute (gpm) and the system running for 20 years, the RAOs would be met in approximately 45 years.

2.9.1.5 PCE Alternative 5—Phytoremediation, MNA, and ICs

Alternative 5 consists of phytoremediation, MNA, and ICs. Phytoremediation would be completed by planting 300 hybrid poplar trees above the off-Base portion of the PCE Plume. Remediation of the plume outside of this area would be by MNA. It is expected that the RAOs would be met in less than 65 years.

2.9.1.6 PCE Alternative 6—In Situ Treatment, MNA, and ICs

Alternative 6 consists of targeted in situ treatment in addition to MNA and ICs. Carbon substrate injections for ERD would be completed in areas of high PCE concentrations on-Base and mid-plume off-Base to reduce the mass of PCE. On-Base injections would be completed in proximity to Monitoring Well U9-12-006. Injections in the mid-plume area (off-Base) would be implemented at approximately the same area where the 2007 treatability study was performed (CH2M HILL 2009b). A treatability study is being performed at OU 10 to evaluate possible substrates and dosing scenarios for ERD. The RAOs would be met in approximately 32 years.

2.9.2 Shallow TCE Remedial Alternatives

2.9.2.1 Shallow TCE Alternative 1—No Action

Alternative 1 consists of taking no further action. This alternative serves as a baseline for evaluating alternatives and is required by the NCP.

2.9.2.2 Shallow TCE Alternative 2—MNA and ICs

Alternative 2 includes MNA and continued groundwater use restrictions. The RAOs would be met in approximately 74 years.

2.9.2.3 Shallow TCE Alternative 3—Groundwater Extraction and Discharge, MNA, and ICs

Alternative 3 consists of installing three groundwater extraction and discharge wells designed to reduce the remediation timeframe by reducing contaminant mass from the on-Base portions of the Shallow TCE Plume. Extracted groundwater would be pretreated if any pretreatment limits would be exceeded when discharged to the sanitary sewer for treatment at the local POTW. The MNA component of this alternative consists of allowing portions of the plume to naturally attenuate. With a combined extraction rate of 25 gpm and the systems running for 5 years, the RAOs would be met in approximately 64 years.

2.9.2.4 Shallow TCE Alternative 4—In Situ Treatment, MNA, and ICs

Alternative 4 consists of targeted in situ treatment at areas of high TCE concentrations. Carbon substrate injections to enhance biodegradation would be completed at the core of the TCE Plume using two corridors of injection wells. For cost estimation purposes, the injections were assumed to create a target treatment zone approximately 10–35 ft bgs and totaling approximately 540 linear ft using 30 injection wells. Injection wells would be installed in side streets along 200 West and 600 North in the City of Clearfield. The RAOs would be met in approximately 51 years.

2.9.3 Deep TCE Remedial Alternatives

2.9.3.1 Deep TCE Alternative 1—No Action

Alternative 1 consists of taking no further action. This alternative serves as a baseline for evaluating alternatives and is required by the NCP.

2.9.3.2 Deep TCE Alternative 2—MNA and ICs

Alternative 2 includes MNA and ICs. ICs would be maintained. The RAOs for this alternative would be met in approximately 67 years.

2.9.3.3 Deep TCE Alternative 3—Enhanced In Situ Bioremediation Containment, MNA, and ICs

Alternative 3 consists of in situ bioremediation through the installation of approximately 67 injection wells that would deliver a biological substrate to create a 2,000-ft-wide biological barrier at the toe of the Deep TCE Plume. Natural attenuation of the TCE Plume would continue to be monitored and the progress toward meeting the RAOs evaluated. The estimated remedial timeframe for this alternative is also approximately 67 years.

2.9.3.4 Deep TCE Alternative 4—One-Well Hydraulic Containment, MNA, and ICs

Alternative 4 is intended to provide a reduction in plume migration by installing one extraction well at the toe of the Deep TCE Plume. Extracted, untreated groundwater would be discharged to the sanitary sewer for treatment at the local POTW, with sampling and analysis to ensure that the discharged water meets POTW pretreatment requirements. Attenuation of the TCE Plume would continue to be monitored and the progress toward meeting the RAOs evaluated. With an assumed extraction rate of 100 gpm and the system running for 30 years, the RAOs would also be met in approximately 67 years.

2.9.3.5 Deep TCE Alternative 5—Three-Well Hydraulic Containment, MNA, and ICs

The objective of Alternative 5 is to enhance the containment and restoration timeframe evaluated in Alternative 4 by installing three extraction wells. Extracted, untreated groundwater would be discharged to the sanitary sewer for treatment at the local POTW, with sampling and analysis to ensure that the discharged water meets POTW pretreatment requirements. Attenuation of the TCE Plume would continue to be monitored and the progress toward meeting the RAOs evaluated. With a combined extraction rate of 210 gpm and the systems running for 30 years, the RAOs would be met in approximately 64 years.

2.9.4 Common Elements of Remedial Alternatives

There are several common remedial components to all of the remedial alternatives (except for the No Action Alternative), including the following:

- Remedial action operations (RA-O) performance monitoring
- Continuation of ICs
- MNA for dissolved-phase plumes.

The following paragraphs discuss further details about each of these common elements.

2.9.4.1 RA-O Performance Monitoring

A robust RA-O performance monitoring plan will track progress toward achieving RAOs. Performance evaluation of the approved remedies will be presented in a Remedial Design/Remedial Action Work Plan.

2.9.4.2 Institutional Controls

ICs are used when contamination remains onsite at a level that does not allow for unlimited use and unrestricted exposure The USAF is responsible for implementing, monitoring, maintaining, reporting on, and enforcing the ICs on-Base, including specific actions as described in the Base General Plan and the Restricted Areas Use Map. For groundwater plumes extending off Base, Utah DWRi has restrictions on the installation of new wells and does not permit installation of wells in the off-Base areas of the shallow aquifer groundwater contamination as described in more detail below. However, the USAF is responsible for ensuring that ICs that are part of this ROD, but are performed by other parties, are established, monitored, maintained and reported on to ensure protection of human health and the environment. The USAF will retain ultimate responsibility for remedy integrity. The USAF shall inform, monitor, enforce, and bind, where appropriate, authorized lessees, tenants, contractors, and other authorized occupants of the site regarding the ICs affecting the site. Where State agencies bear a significant enforcement role, the USAF will maintain regular communication with the State agencies and request appropriate notification of enforcement actions. If the USAF and EPA determine that specific IC requirements are not being met, it is understood that the remedy may be reconsidered and that additional measures may be required to protect human health and the environment.

ICs would be included in all remedial alternatives except the No Action Alternative (Alternative 1). The objective of these ICs is to:

- Prevent access or use of shallow groundwater until cleanup levels are met

- Maintain the integrity of any current or future remedial monitoring systems for groundwater or soil gas

- Ensure new construction projects over the on-Base areas of soil gas exceeding RGs take into account the potential for vapor intrusion risks.

Since Hill AFB is expected to remain under the jurisdiction of the Department of Defense for the foreseeable future, the future on-Base land use for OU 10 is expected to be industrial and/or commercial. The ICs selected to protect human health and the environment have taken these potential future land use scenarios into account. These ICs include such actions as USAF-enforced restrictions preventing access to groundwater, review of construction projects potentially impacting contaminated soil or groundwater, and evaluation and mitigation of vapor intrusion risks for future construction. Outside the boundary areas for PCE and TCE where soil gas concentrations exceed RGs (Figure 2-8), specific land use prohibitions are not necessary for OU 10 based on the risk assessment conclusions. ICs will be maintained until contaminant concentrations in groundwater and on-Base soil gas are at levels that allow for unlimited use and unrestricted exposure.

ICs prohibiting use of shallow groundwater within OU 10 have been instituted to prevent exposure until contaminants are at concentrations that allow for unlimited use and unrestricted exposure. The current extent of ICs is shown on Figure 2-8. Groundwater monitoring is used to track the direction and rate of movement of each contaminant plume. These restrictions will remain in place and be monitored for effectiveness until contaminant concentrations in groundwater are at levels that allow for unlimited use and unrestricted exposure.

The off-Base ICs will include the following measures:

- Utah DWRi restrictions on the installation of new wells in the shallow aquifer in off-Base areas will be maintained as described in the Utah DWRi documentation. State water rights and well drilling restrictions will be maintained to prevent human exposure to off-Base groundwater from the shallow aquifer containing COC concentrations above the MCL. The Utah DWRi regulates appropriation and distribution of all water within the State of Utah and has developed a groundwater management plan entitled, Ground-Water Management Plan for the Weber Delta Sub-Area of the East Shore Area (Utah DWRi 1995), which includes the off-Base areas of groundwater contamination associated with Hill AFB. This plan does not permit installation of wells in the off-Base areas of the shallow aquifer in areas of groundwater contamination associated with OU 10 (and other Hill AFB OUs). The USAF will send a letter to the Utah DWRi annually requesting verification of continuing enforcement of these restrictions throughout the life of the remedy, though the USAF will ultimately be responsible for maintaining the integrity of the remedy.

The internal procedures that the Hill AFB will use to implement the LUCs include but are not limited to the following:

- The USAF will maintain maps of the geographic extent of the OU in the geographic information system database. This information will be included in the Base Comprehensive (or General) Plan to ensure that the USAF planners are aware of the OU and of the restrictions of activities within the OU.

- The USAF will update and distribute to Base organizations a Restricted Areas Use Map identifying areas where soil and groundwater contamination may be encountered, or where remedial systems are present.

- The USAF will review all construction proposals using the Base Civil Engineer Work Order request form (USAF Form 332) to address potential risks due to soil gas at the site. Evaluation and mitigation of future vapor intrusion risk is required before any construction over areas with soil gas exceeding the RG (Figure 2-1). If an unacceptable vapor intrusion risk is identified, mitigation measures could include removing the source of soil gas contamination before construction or implementing physical controls during construction of the buildings (i.e., passive or active sub-slab vapor mitigation). No unacceptable risks caused by vapor intrusion have been identified for current workers.

The USAF will notify the EPA and UDEQ in advance of any changes to internal procedures associated with the selected remedies that might affect the LUCs.

Monitoring of the ICs will be conducted annually by the USAF. Monitoring results will be included in a separate report or as a section of another environmental report, if appropriate, and provided to the EPA and UDEQ. Annual monitoring reports will be used in preparation of the Five-Year Review to evaluate the effectiveness of the remedy. The annual monitoring report, submitted to the regulatory agencies by the USAF, will evaluate the status of ICs and how any IC deficiencies or inconsistent uses have been addressed. The annual evaluation will address whether the ICs referenced above were communicated in the deed(s), whether the owners and state and local agencies were notified of the ICs affecting the property, and whether use of the property has conformed to such restrictions and controls.

Breaches of Institutional Controls. Any activity that is inconsistent with the IC objectives or use restrictions, or any other action that may interfere with the effectiveness of the ICs will be addressed by the USAF as soon as practicable, but in no case will the process be initiated later than 10 days after the USAF becomes aware of the breach. The USAF will notify the EPA and the UDEQ as soon as practicable, but no longer than 10 days after discovery, of any activity that is inconsistent with the IC objectives or use restrictions, or any other action that may interfere with the effectiveness of the ICs. The Air Force will notify the EPA and UDEQ regarding how the Air Force has addressed or will address the breach within 10 days of sending EPA and UDEQ notification of the breach.

Land Use Changes and Transfers. The USAF must provide notice to the EPA and UDEQ at least 6 months prior to any transfer or sale of property associated with OU 10 so that the EPA and UDEQ can be involved in discussions to ensure that appropriate provisions are included in the transfer or conveyance documents to maintain effective ICs. If it is not possible for the USAF to notify the EPA and UDEQ at least 6 months prior to any transfer or sale, then the USAF will notify the EPA and UDEQ as soon as possible but no later than 60 days prior to the transfer or sale of any property subject to ICs. The USAF agrees to provide the EPA and UDEQ with such notice, within the same timeframes, for federal-to-federal transfer of property accountability. In the case of federal to federal transfers, there is no deed transfer as the property continues to be owned by the U.S. Government. However, there is a document called a transfer assembly which is used to transfer the property from one federal agency to another. The USAF shall provide a copy of executed deed or transfer assembly to the EPA and UDEQ.

Although the USAF may later transfer procedural responsibilities to another party by contract, agreement, or through other means, the USAF shall retain ultimate responsibility for remedy integrity. The USAF shall notify the EPA and UDEQ 45 days in advance of any proposed land use changes that are inconsistent with LUC objectives or the selected remedy.

Modification or Termination. Hill AFB shall not modify or terminate ICs, implementation actions, or land use that are associated with the selected remedy without the approval of the EPA and opportunity for concurrence by the UDEQ. Hill AFB will seek prior approval by the EPA and concurrence from the UDEQ before any anticipated action that may disrupt the effectiveness of the ICs or any action that may alter or negate the need for ICs.

2.9.4.3 Monitored Natural Attenuation

MNA is the process by which contaminant concentrations are reduced by various naturally occurring physical, chemical, and biological processes. Natural attenuation relies upon natural processes without human intervention to assist in the reduction of contaminant concentrations. However, natural attenuation processes will be carefully monitored to evaluate their effectiveness. The application of this method depends on site-specific data (i.e., type, concentration, and interaction of contaminants) and the biological, chemical, and physical characteristics of the site. Fuel-related VOCs and chlorinated solvents, such as TCE, are commonly evaluated for natural attenuation. As summarized in Section 2.5.2.3, evidence of natural attenuation occurring at OU 10 was evaluated in the FS Report (CH2M HILL 2009b).

MNA is included as a component of all of the remedial alternatives except Alternative 1 (No Action). A select number of existing monitoring wells will be sampled for the RA-O performance monitoring of the contaminant plumes. Yearly monitoring of these monitoring wells was assumed for cost estimating purposes; the actual number of wells and sampling frequencies will be determined during the development of the remedial design for the selected alternative. Natural attenuation of the TCE, PCE, cis-1,2-DCE, and trans-1,2-DCE concentrations will continue to be assessed through RA-O performance monitoring until the RAOs and RGs have been achieved.

2.9.5 Distinguishing Features and Expected Outcomes of Remedial Alternatives

Tables 2-12 through 2-14 present distinguishing features of each alternative, including alternative descriptions, key ARARs associated with each plume-specific alternative, estimated time for design and construction, estimated time to reach RAOs, the estimated capital costs, annual O&M costs, present worth costs, and the expected outcome of each alternative.

As shown in Tables 2-12 through 2-14, key ARARs vary from alternative to alternative. The relative performance of each alternative is described in detail in Section 2.10, which includes a comparative analysis of each alternative against the nine NCP criteria. As shown in Tables 2-12 through 2-14, aside from varying ARARs, the key distinguishing features between each of the alternatives are the capital and total present worth costs. In addition, there is a significant difference in the remedial timeframe between the various alternatives evaluated for each plume.

2.10 Summary of Comparative Analysis of Alternatives

In accordance with the NCP, alternatives for Hill AFB OU 10 were evaluated using the nine criteria described in Section 121(b) of CERCLA and the NCP Section 300.430(f)(5)(i). These criteria are classified as threshold criteria, balancing criteria, and modifying criteria.

Threshold criteria are standards that an alternative must meet to be eligible for selection as a remedial action. There is little flexibility in meeting the threshold criteria—the alternative must meet them or it is unacceptable. The following are classified as threshold criteria:

- Overall protection of human health and the environment

- Compliance with ARARs.

Balancing criteria weigh the tradeoffs between alternatives. These criteria represent the standards upon which the detailed evaluation and comparative analysis of alternatives are based. In general, a high rating on one criterion can offset a low rating on another balancing criterion. Five of the nine criteria are considered balancing criteria:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume (TMV) through treatment
- Short-term effectiveness
- Implementability
- Cost.

Modifying criteria are as follows:

- Community acceptance
- State/support agency acceptance.

This section summarizes how well each alternative satisfies each evaluation criterion and indicates how it compares to the other alternatives under consideration. An overview of the criteria evaluation is presented in Tables 2-15 through 2-17 for the PCE Plume, Shallow TCE Plume, and Deep TCE Plume, respectively.

2.10.1 Overall Protection of Human Health and the Environment

2.10.1.1 PCE Plume

All of the alternatives screened, with the exception of the No Action Alternative, are protective of human health and the environment by reducing or controlling risks posed by the site through treatment, MNA, and/or LUCs. Alternative 1 is not protective of human health and the environment due to the lack of groundwater monitoring, the potential for unknown exposure, and discontinued enforcement of ICs. Without the collection of data, achieving RAOs would not be demonstrated. Based on this determination, Alternative 1 is not evaluated further. Alternatives 2 through 6 comply with all RAOs and meet this threshold criterion. These alternatives prevent exposure to contaminated water (RAO 1) and minimize potential on-Base exposure to volatile OU 10-related contaminants (RAO 2) through ICs. Regarding RAO 3, site data indicate the plume is stable. For Alternatives 2 through 6, plume expansion, if any, is estimated to be minimal and within the area of existing ICs. Alternatives 3 through 6 provide active treatment and mass transfer to reduce the concentrations of COCs in groundwater, potentially expediting natural attenuation processes. All alternatives comply with RAO 4 and restore groundwater to its expected beneficial use within a reasonable timeframe. Monitoring and LUCs will provide protection until RAOs are achieved for Alternatives 2 through 6.

2.10.1.2 Shallow TCE Plume

Alternative 1 is not protective of human health and the environment due to the lack of groundwater monitoring, the potential for unknown exposure, and discontinued enforcement of ICs. Without the collection of data, achieving RAOs would not be demonstrated. Based on this determination, Alternative 1 was not evaluated further. Alternatives 2 through 4 comply with all RAOs and meet this threshold criterion. These alternatives comply with RAOs 1 and 2 through ICs. Regarding RAO 3, site data indicate the plume is stable. For Alternatives 2 through 4, plume expansion, if any, is estimated to be minimal and within the area of existing ICs. Alternatives 3 and 4 also satisfy RAO 3 through active treatment and mass transfer to reduce the concentrations of COCs in groundwater, potentially expediting natural attenuation processes. All alternatives comply with RAO 4 and restore groundwater to its expected beneficial use within a reasonable timeframe. Monitoring and LUCs will provide protection until RAOs are achieved for Alternatives 2 through 4.

2.10.1.3 Deep TCE Plume

Alternative 1 is not protective of human health and the environment due to the lack of groundwater monitoring, the potential for unknown exposure, and discontinued enforcement of ICs. Without the collection of data, achieving RAOs would not be demonstrated. Based on this determination, Alternative 1 was not evaluated further. Alternatives 2 through 5 can achieve RAOs and meet this threshold criterion. Alternatives 3 through 5 provide active treatment and mass transfer to reduce the concentrations of COCs in groundwater, potentially expediting natural attenuation processes. Monitoring and LUCs will provide protection until RAOs are achieved for Alternative 2 through 5.

2.10.2 Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and 40 CFR 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA Section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. State standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those documented at the CERCLA site (relevant) that their use is well suited (appropriate) to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes or provides a basis for invoking a waiver. Key ARARs for all remedies are shown in Tables 2-12 through 2-14.

For the three OU 10 plumes, all evaluated alternatives comply with location-, action-, and chemical-specific ARARs as aquifer restoration will be achieved in a reasonable timeframe, restrictions to groundwater use are in place, and remedial actions (e.g., injection of treatment chemicals or discharge of extracted groundwater) would occur in compliance with federal and state standards.

For the PCE Plume, the anticipated timeframes to achieve chemical-specific ARARs for the evaluated alternatives range from 32 to 65 years. For the Shallow TCE Plume, the anticipated timeframes to achieve chemical-specific ARARs range from 51 to 74 years. For the Deep TCE Plume, the anticipated timeframes to achieve chemical-specific ARARs range from 64 to 67 years.

2.10.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

2.10.3.1 PCE Plume

Alternatives 2 through 6 all have moderate to good long-term effectiveness in the PCE Plume, primarily because they have the potential to achieve the RAOs and permanently reduce PCE concentrations below the MCL without leaving long-term residual contamination. The targeted substrate injections in Alternative 6 could result in the temporary mobilization of metals (e.g., ferrous iron, manganese, and arsenic) and the generation of degradation products of PCE through reductive dechlorination, such as TCE, cis-1,2-DCE and vinyl chloride. However, the mobilization of metals and generation of degradation products would likely be localized and temporary. The generation and attenuation of metals and degradation products would be monitored as part of Alternative 6. The mobilized metals and degradation products are expected to rapidly attenuate under naturally aerobic conditions present away from the treatment areas and are therefore not expected to impact the long-term effectiveness of Alternative 6.

2.10.3.2 Shallow TCE Plume

Alternatives 2 through 4 have moderate to good long-term effectiveness in the Shallow TCE Plume, primarily because they have the potential to achieve the RAOs and permanently reduce TCE concentrations below the MCL without leaving long-term residual contamination. The targeted substrate injections in Alternative 4 could result in the temporary mobilization of metals (e.g., ferrous iron, manganese, and arsenic) and the generation of degradation products of TCE through reductive dechlorination, such as cis-1,2-DCE and vinyl chloride. However, the mobilization of metals and generation of degradation products would likely be localized and temporary. The generation and attenuation of metals and degradation products would be monitored as part of Alternative 4. The mobilized metals and degradation products are expected to rapidly attenuate under naturally aerobic conditions present away from the treatment areas and are therefore not expected to impact the long-term effectiveness of Alternative 4 for the Shallow TCE Plume.

2.10.3.3 Deep TCE Plume

All evaluated alternatives are expected to be effective in the long term in the Deep TCE Plume. All alternatives will achieve long-term effectiveness because they have the potential to achieve the RAOs and permanently reduce TCE concentrations below the MCL without leaving long-term residual contamination. Alternatives 2, 3, and 4 have a remediation timeframe of 67 years and Alternative 5 has a remediation timeframe of 64 years, which is only a 3-year improvement. This indicates that active treatment has little benefit over the time to achieve RAOs.

2.10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of TMV through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

2.10.4.1 PCE Plume

Alternatives 3 through 6 would reduce TMV through treatment in the PCE Plume. Alternative 2 relies solely on natural attenuation mechanisms to reduce toxicity of contaminants (which is not "treatment" as that term means active measures taken to reduce TMV). An evaluation of natural attenuation mechanisms completed in the RI Report (CH2M HILL 2009a) and FS Report (CH2M HILL 2009b) indicated intrinsic phytoremediation might be occurring at the PCE Plume. Alternatives 3 through 6 provide active treatment to reduce the mass of PCE and inhibit migration; however, the targeted source area and mid-plume in situ injections in Alternative 6 are estimated to degrade PCE faster than the other alternatives. For this reason, Alternative 6 was given a higher rating for the reduction of TMV than the other alternatives. As discussed in the evaluation of long-term effectiveness, Alternative 6 could temporarily generate degradation products, but the generation of these degradation products would likely be localized and temporary.

2.10.4.2 Shallow TCE Plume

All alternatives would reduce TMV through natural attenuation mechanisms (which is not "treatment" as that term means active measures taken to reduce TMV) in the Shallow TCE Plume. Alternative 2 relies solely on natural attenuation mechanisms to reduce toxicity and mass of contaminants. An evaluation of natural attenuation mechanisms completed in the OU 10 RI Report (CH2M HILL 2009a) and OU 10 FS Report (CH2M HILL 2009b) indicated decreases in TCE mass over time, plume stability, and evidence that aerobic cometabolism of TCE is occurring. Alternatives 3 and 4 would further reduce TMV through treatment. As discussed in the evaluation of long-term effectiveness, Alternative 4 could temporarily generate treatment degradation products, but the generation of these degradation products would likely be localized and temporary. Alternative 4 treats the contaminants directly through in situ treatment of the groundwater, and therefore, was given a higher ranking for reduction of TMV through treatment.

2.10.4.3 Deep TCE Plume

All alternatives would reduce TMV through natural attenuation mechanisms (which is not "treatment" as that term means active measures taken to reduce TMV) in the Deep TCE Plume. Alternatives 3 through 5 would further reduce TMV through treatment. Alternative 2 relies solely on natural attenuation mechanisms to reduce toxicity and mass of contaminants. An evaluation of natural attenuation mechanisms completed in the RI Report (CH2M HILL 2009a) and FS Report (CH2M HILL 2009b) indicated that different microbial degradation processes are occurring in the Lower Zone. It is likely that complete biodegradation of TCE and its daughter products is occurring through a variety of degradation pathways supported by a diverse consortium of microbial groups. Alternatives 3, 4, and 5 provide active treatment, but, as mentioned previously, the reduction in remedial timeframe is minimal.

2.10.5 Short-Term Effectiveness

Short-term effectiveness addresses the period needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved. It also addresses the time required to achieve RAOs.

2.10.5.1 PCE Plume

Alternatives 2 and 5 in the PCE Plume present minimal short-term risk to the community and workers because these alternatives consist of generally passive treatment technologies and therefore present negligible risk of exposure to contaminated media or other health, safety, and environmental impact risks. However, Alternative 5 would likely require more operation and maintenance than Alternative 2 and therefore has a greater degree of potential impacts to the environment from non-renewable fuel use than Alternative 2. While Alternatives 2 and 5 present minimal risks to workers, the community, and to the environment, the estimated remedial timeframes are long relative to the other alternatives. This relatively long estimated remedial time counteracts the minimal risks; therefore, these alternatives were given "Moderate/Adequate" short-term effectiveness rankings. Alternative 4 presents some short-term health and safety risks, risk of exposure to contaminated media, and risk of environmental impact while constructing the extraction well, trenching, and installing the discharge conveyance pipeline. These risks can be controlled, but not eliminated, by following standard health and safety practices and proper construction safety measures and by implementing appropriate traffic plans.

Alternatives 3 and 6 present potential, but unlikely, impacts to the community and to the environment through transportation of the treatment chemical (e.g., iron for the PRB and chemicals or substrate for in situ treatment). Impacts to workers include risk associated with handling the chemicals during trenching/injection activities (Alternative 3), working in proximity to a road, and waste handling.

Alternative 6 would be expected to result in reductive dechlorination, which can cause buildup of daughter products; however, the generation of daughter products is expected to be localized to the treatment area and temporary, similar to the observations during the 2007 treatability study (CH2M HILL 2009b). Because the pretreatment aquifer conditions are aerobic (CH2M HILL 2009b), concentrations of the byproducts of anaerobic conditions (e.g., mobilized metals or methane) are expected to return to approximately pretreatment levels after reducing conditions no longer persist following the treatment period.

Another potential short-term risk associated with Alternative 6 is vapor intrusion into buildings and residential properties through the generation of gaseous COCs, including PCE, TCE, and vinyl chloride and other gaseous byproducts, such as methane. These risks would be monitored near the treatment area with soil gas probes and could be mitigated if necessary using soil vapor extraction (SVE) and/or a vapor removal system (VRS) on commercial or government property or by installing a VRS at any residential property if detections of gaseous byproducts were found above Mitigation Action Levels as defined by the EPA. Specific details outlining vapor detection levels and mitigation action thresholds for installing an SVE system or a VRS system will be presented in the OU 10 Remedial Design (RD)/Remedial Action (RA) Work Plan. Off-Base injections in Alternative 6 would be completed in a commercial property, which should pose a limited impact to the local community.

Alternative 6 has good short-term effectiveness because there are adequate controls using proven technologies for the associated risks and the remediation timeframe is shorter than Alternatives 2 through 5 (32 years compared with 45 to 65 years).

2.10.5.2 Shallow TCE Plume

Alternative 2 in the Shallow TCE Plume presents minimal short-term risk to the community or workers because work is limited to monitoring. Alternative 3 presents some short-term risks to workers while constructing the extraction wells, trenching, and installing the discharge conveyance pipeline. These risks can be controlled, but not eliminated, by following standard health and safety practices and proper construction safety measures and by implementing appropriate traffic plans. Alternative 4 presents potential, but unlikely, impacts to the community and to the environment through transportation of the treatment chemical or substrate. Impacts to workers also include risk associated with working in proximity to a road and waste handling. Off-Base work would be completed in a manner to minimize impact to the community (minimize impact to traffic and access).

Alternative 4 would be expected to result in reductive dechlorination, which can cause buildup of daughter products; however, the generation of daughter products is expected to be localized to the treatment area and temporary, similar to the observations during the 2007 treatability study (CH2M HILL 2009b). Because the pretreatment aquifer conditions are aerobic (CH2M HILL 2009b), concentrations of the byproducts of anaerobic conditions (e.g., mobilized metals or methane) are expected to return to approximately pretreatment levels after reducing conditions no longer persist following the treatment period.

A potential short-term risk associated with Alternative 4 is vapor intrusion into buildings and residential properties through the generation of gaseous COCs, including PCE, TCE, and vinyl chloride and other gaseous byproducts, such as methane. These risks would be monitored near the treatment area with soil gas probes and could be mitigated if necessary using SVE and/or a VRS on commercial or government property or by installing a VRS at any residential property with detections of gaseous byproducts above Mitigation Action Levels as defined by the EPA. Specific details outlining vapor detection levels and mitigation action thresholds for installing an SVE system or a VRS system will be presented in the OU 10 RD/RA Work Plan.

Alternative 4 has good short-term effectiveness because there are adequate controls using proven technologies for the associated risks and the remediation timeframe is shorter than Alternatives 2 and 3 (51 years compared to 64 to 74 years).

2.10.5.3 Deep TCE Plume

Alternative 2 in the Deep TCE Plume presents minimal short-term risk to the community or workers because work is limited to monitoring. For Alternative 3, impacts to the community include traffic of heavy-duty vehicles for substrate delivery. Impacts to workers include risks associated with handling large volumes of substrate. Alternatives 4 and 5 pose minimal impacts to the community; however, these alternatives pose risks to workers from well placement in proximity to an active railroad. However, these risks can be mitigated through proper work safety processes. However, Alternative 2 presents the best short-term effectiveness, since it poses less risk than the other alternatives.

2.10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

2.10.6.1 PCE Plume

Alternatives 2 through 6 are implementable in the PCE Plume. Alternatives 2 and 4 are easily implemented both technically and administratively. Challenges associated with Alternative 3 include installing a trenched barrier in a residential area with multiple utilities. Challenges associated with Alternative 5 include obtaining multiple leases to plant trees on private property and maintenance involved with upkeep of planted trees. The technology and substrate needed to implement Alternative 6 are widely available and should be generally feasible to execute within city streets and commercial property. Implementation of work off-Base would require close communication and coordination with all stakeholders, including property owners and city and state representatives. Technical challenges can include adequate subsurface distribution of the substrate.

2.10.6.2 Shallow TCE Plume

Alternatives 2, 3, and 4 are implementable in the Shallow TCE Plume. There are no technical or administrative challenges with Alternative 2. The approach for Alternative 3 has been demonstrated at other OUs at Hill AFB. The technology and substrate to implement Alternative 4 are widely available and should be feasible to execute. Implementation of work off-Base would require close communication and coordination with all stakeholders, including property owners and city and state representatives. Technical challenges can include adequate subsurface distribution of the substrate.

2.10.6.3 Deep TCE Plume

Alternatives 2, 3, 4, and 5 are implementable in the Deep TCE Plume. There are no technical or administrative challenges with Alternative 2. For Alternative 3, it could be technically challenging to have a uniform distribution of substrate at the required depth and there would be a high level of insurance requirements and safety considerations associated with implementing the remedial alternative in proximity to residential homes. Alternatives 4 and 5 are technically and administratively feasible options, and use of this approach has been demonstrated at other OUs at Hill AFB.

2.10.7 Cost

The capital, O&M, and net present value costs for each alternative are presented in Tables 2-15, 2-16, and 2-17 for the PCE Plume, Shallow TCE Plume, and Deep TCE Plume, respectively. Detailed cost estimates for the remedial alternatives of each site are presented in the FS Report (CH2M HILL 2009b) or FS Supplement (EA 2014a). The cost estimates are based on the best available information regarding the anticipated scope of the remedial alternative. These estimates are expected to be within +50 to -30 percent of the actual project cost as recommended by EPA guidance (1999a). Summaries of the comparative costs for the alternatives for each plume are presented below.

2.10.7.1 PCE Plume

There are no costs for Alternative 1 because no actions are taken. The present worth cost of Alternative 2 is approximately \$2.8 million, with most of the cost associated with RA-O performance monitoring. Alternative 6 is the most cost-effective alternative with a net present worth cost of \$1.6 million. The present worth cost for Alternative 3 is the highest at approximately \$8.9 million. As presented in Appendix B, the estimated costs of Alternative 2 (MNA and ICs) and Alternative 6 (In Situ Treatment, MNA, and ICs) are lower than the other alternatives because Alternative 2 includes only a small estimated capital cost for installation of additional monitoring wells, and Alternative 6 incurs lower estimated O&M costs than the other alternatives. The estimated cost of Alternative 3 (PRB, MNA, and ICs) is higher than the other alternatives due to the high estimated costs associated with installing the PRB and replacing the PRB over time.

2.10.7.2 Shallow TCE Plume

There are no costs for Alternative 1 because no actions are taken. The present worth cost of Alternative 2 is approximately \$3.9 million, with most of the cost associated with RA-O performance monitoring. The present worth cost for Alternative 3 is the highest at approximately \$5.5 million. Alternative 4 is the most cost-effective alternative with a present worth cost of \$2.3 million. As presented in Appendix B, the estimated cost of Alternative 4 (In Situ Treatment, MNA, and ICs) is lower than the other alternatives due to the lower estimated O&M costs for this alternative. The estimated cost of Alternative 3 (groundwater extraction and direct discharge [GED], MNA, and ICs) is highest due to the relatively high estimated costs for O&M for this alternative.

2.10.7.3 Deep TCE Plume

There are no costs for Alternative 1 because no actions are taken. The present worth cost of Alternative 2 is approximately $2.8 million, with most of the cost associated with RA-O performance monitoring. Costs associated with Alternatives 4 and 5 are relatively similar ($8.7 million and $11.4 million, respectively); the difference is associated with the construction and operation of two additional extraction wells. Overall costs for Alternative 3 are significantly higher than the other proposed alternatives ($36.2 million). The costs are primarily driven by the long barrier length, the high number of injection wells required, and the large volume of substrate required.

2.10.8 State/Support Agency Acceptance

The EPA approves and UDEQ concurs with the selected remedies:

- PCE Alternative 6—In Situ Treatment, MNA, and ICs
- Shallow TCE Alternative 4—In Situ Treatment, MNA, and ICs
- Deep TCE Alternative 2—MNA and ICs.

2.10.9 Community Acceptance

Public comment on the Proposed Plan for OU 10 (EA 2015a) was solicited to evaluate community acceptance of the preferred alternatives. The public meeting was held on 5 March 2015 at the Clearfield City Office. A sign-in sheet with the names of those in attendance at the public meeting is included in Appendix C. The public comment period was held from 14 February to 15 March 2015. No comments were received during the public meeting, nor were any comments received during the public comment period.

2.11 Principal Threat Wastes

The NCP expects that treatment resulting in a reduction in TMV of the principal threat wastes will be used to the extent practicable. The principal threat concept refers to the source materials at a CERCLA site considered highly toxic or highly mobile that generally cannot be reliably controlled in place or present a significant risk to human health or the environment should exposure occur (EPA 1999a).
A source material is material that contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater or air, or that acts as a source for direct exposure. The only potential principal threat waste, contaminated soils, was removed along with the former OWS near Building 1244, as previously mentioned. Considering the nature of the releases and the relatively low PCE and TCE concentrations in groundwater at the site, dense non-aqueous phase liquid is not thought to be present. Based on these results, there are no principal threat wastes remaining at OU 10.

2.12 Selected Remedies

The goal of the selected remedies for OU 10 is to restore groundwater to RGs within a reasonable timeframe while preventing potential exposure to contaminated groundwater. This section describes the selected remedies for the three groundwater plumes within OU 10 and provides specific performance measures for the selected remedies. The common elements for each of the alternatives are presented in Section 2.9.4.

The selected remedies for OU 10 include the following:

- PCE Alternative 6—In situ treatment for mass removal by biodegradation, MNA to monitor plume stability/attenuation, and ICs to prevent groundwater exposure until MCLs are achieved

- Shallow TCE Alternative 4—In situ treatment for mass removal by biodegradation, MNA to monitor plume stability/attenuation, and ICs to prevent groundwater exposure until MCLs are achieved

- Deep TCE Plume Alternative 2—MNA to monitor plume stability/attenuation and ICs to prevent groundwater exposure until MCLs are achieved.

The USAF, EPA, and UDEQ believe that the selected remedies meet the threshold criteria and provide a good balance of tradeoffs with respect to the balancing and modifying criteria. The remedies are expected to satisfy the statutory requirements of CERCLA Section 121(b) (Section 2.13). Figure 2-8 shows the implementation locations of the selected active remedies.

2.12.1 PCE Plume

2.12.1.1 Description of the Selected Remedy

The selected remedy for the PCE Plume (Alternative 6) involves in situ treatment, MNA, and ICs. The objective of Alternative 6 is to target and treat hot-spot concentrations within the plume to reduce the PCE Plume restoration timeframe and limit potential future plume expansion. In situ treatment by carbon substrate injections will be completed in areas of high PCE concentrations on-Base (source area) and mid-plume (off-Base) to reduce the mass of PCE (Figure 2-8). On-Base injections will be completed in proximity to Monitoring Well U9-12-006. Injections in the mid-plume area will be implemented at approximately the same area where the 2007 treatability study was performed (CH2M HILL 2009b) at a commercial property west of Main Street in Clearfield. For cost estimation purposes, the injections were assumed to create a target treatment zone approximately 20 to 30 ft bgs and about 150 ft wide using approximately 8 injection wells spaced approximately 20 ft apart. However, final design and treatment location will be documented in the Remedial Design/Remedial Action Work Plan. Additional substrate injections will take place, if necessary, to continue the promotion of ERD to achieve target contaminant concentration reductions at specific locations that will be established in the Remedial Design/Remedial Action Work Plan prior to performing the work. Attenuation of the groundwater outside of the treatment zones would be achieved by MNA. ICs to prohibit groundwater use would remain in place until RAOs are achieved. The estimated remedial timeframe for Alternative 6 is 32 years. This timeframe is driven by natural attenuation outside of the treatment zone at Monitoring Well U10-133; found on Figure 2-8 (PCE concentration of 24 μg/L in 2013). Additional details regarding how remedial timeframes were estimated may be found in the OU 10 FS Supplement (EA 2014a).

A treatability study was performed in 2014 at OU 10 to evaluate possible substrates and dosing scenarios for ERD. The purpose of the study was to evaluate a substrate and dose combination that promotes ERD conditions that will reduce PCE and TCE concentrations. Results from this treatability study will be used to optimize the full-scale remedial design and assist with the selection of a suitable injectate. Overall, the treatability study demonstrated that carbon substrate injection, combined with bioaugmentation, resulted in complete reductive dechlorination of PCE in the injection well without generating hazardous by-products at concentrations of concern (EA 2015b).

For cost estimating purposes, Lact*Oil*® was assumed as the carbon substrate, and bioaugmentation was not included. The generation of gaseous byproducts within soil gas will be monitored and, if concentrations exceed screening levels, mitigated with an SVE system and/or VRS. Specific details outlining vapor detection levels and mitigation action thresholds for installing an SVE system or a VRS system will be presented in the OU 10 RD/RA Work Plan. Off-Base injections in Alternative 6 would be completed at the Universal Rent-All commercial property (currently operating), which should pose a limited impact to the local community.

RA-O performance monitoring will be conducted during treatment to measure the effectiveness of the remedy. This includes monitoring changes in PCE concentrations as well as the production of PCE degradation products. In addition to treatment system performance monitoring, changes in aquifer conditions would be monitored to allow for the evaluation of natural degradation of the contaminants (including breakdown by-products) outside of the treatment zone. Frequency of sampling, analytical parameters, and the monitoring well network will be determined in the remedial design. The ICs described in Section 2.9.4.2 will be maintained until RAOs are achieved. The remedy will be considered complete when groundwater PCE concentrations at or below 5 μg/L are achieved and observed to be stable or decreasing with no likely rebound.

2.12.1.2 Summary of Estimated Remedy Costs

The present worth cost of PCE Alternative 6 is approximately $1.6 million (Appendix B). As documented in Appendix B and in Table 2-15, the capital cost is estimated as $0.9 million. The O&M cost varies by year; the total O&M cost is estimated as $0.7 million. The present worth cost was calculated using a 1.1 percent discount rate and an estimated remedial timeframe of 32 years. The cost is an order-of-magnitude engineering estimate that is expected to be within +50 to -30 percent of the actual project cost, and was prepared based on available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements may occur based on new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences (ESD), or a ROD Amendment.

2.12.1.3 Expected Outcomes of Selected Remedy

Current ICs are expected to continue at OU 10. Cleanup levels for the selected remedy for the PCE Plume are based on unlimited use and unrestricted exposure. Exposure will be controlled through ICs until PCE concentrations within groundwater are reduced to 5 μg/L. PCE dehalogenation daughter byproducts will be monitored to verify that their concentrations do not exceed their respective EPA MCLs. Table 2-18 summarizes the unacceptable risks, the RAOs identified to address the risks, the remedy components intended to achieve the RAOs, the metrics that measure the remedial action progress, and the expected outcome of the remedy.

2.12.1.4 Summary of the Rationale for the Selected Remedy

Besides Alternative 1 (No Action), all alternatives considered met the threshold criteria of overall protection of human health and the environment and compliance with ARARs, and are technically and regulatorily implementable (a balancing criteria). However, Alternative 6 (In Situ Treatment, MNA, and ICs) was chosen over other alternatives because it was rated the best in the balancing criteria long-term effectiveness, reduction of TMV through treatment, short-term effectiveness, and had the lowest cost of all alternatives (Table 2-15). In particular, Alternative 6 has the best short-term effectiveness by achieving RAOs in the least time (32 years compared with 45 to 65 years) at the lowest present worth cost ($1.6 million compared to a range from $2.8 million to $8.9 million). In regards to modifying criteria, Alternative 6 has been accepted by the EPA, the UDEQ, and the community.

2.12.2 Shallow TCE Plume

2.12.2.1 Description of the Selected Remedy

The selected remedy for the Shallow TCE Plume (Alternative 4) involves in situ treatment, MNA, and ICs. In situ treatment by carbon substrate injections will be completed at the core of the TCE Plume using two corridors of injection wells located off-Base (Figure 2-8). For cost estimation purposes, the injections were assumed to create a target treatment zone approximately 10–35 ft bgs and totaling about 540 linear feet using 30 injection wells. Injection wells are expected to be installed in side streets along 200 West and 600 North in Clearfield City; however, final design and treatment location will be documented in the Remedial Design/Remedial Action Work Plan. Additional substrate injections will take place as needed, based on RA-O performance monitoring results, to continue the promotion of ERD. For cost estimating purposes, Lact*Oil* was assumed as the carbon substrate.

RA-O performance monitoring will be conducted during treatment to measure its effectiveness and changes in TCE concentrations and to assess sitewide groundwater conditions and trends. TCE dehalogenation daughter byproducts will also be monitored during treatment. In addition to RA-O performance monitoring of the active treatment, MNA will include additional groundwater monitoring and appropriate data analysis to assess natural attenuation processes and plume stability, and evaluate progress toward meeting RAOs. Frequency of sampling, analytical parameters, and the monitoring well network will be determined in the remedial design. The ICs described in Section 2.9.4.2 will be maintained until RAOs are achieved. The remedy will be considered complete when groundwater TCE concentrations at or below 5 μg/L are achieved and observed to be stable or decreasing with no likely rebound.

2.12.2.2 Summary of Estimated Remedy Costs

The present worth cost of Shallow TCE Alternative 4 is approximately $2.3 million (Appendix B). As documented in Appendix B and in Table 2-16, the capital cost is estimated as $0.9 million. The O&M cost varies by year; the total O&M cost is estimated as $1.4 million. The present worth cost was calculated using a 1.1 percent discount rate and an estimated remedial timeframe of 51 years. The cost is an order-of-magnitude engineering estimate that is expected to be within +50 to -30 percent of the actual project cost, and was prepared based on available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements may occur based on new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, an ESD, or a ROD Amendment.

2.12.2.3 Expected Outcomes of Selected Remedy

Current ICs are expected to continue at OU 10. Cleanup levels for the selected remedy for the Shallow TCE Plume are based on unlimited use and unrestricted exposure. Exposure will be controlled through ICs until TCE concentrations within groundwater are reduced to 5 µg/L. Table 2-19 summarizes the unacceptable risks, the RAOs identified to address the risks, the remedy components intended to achieve the RAOs, the metrics that measure the remedial action progress, and the expected outcome of the remedy.

2.12.2.4 Summary of the Rationale for the Selected Remedy

Besides Alternative 1 (No Action), all alternatives considered met the threshold criteria of overall protection of human health and the environment and compliance with ARARs, and are technically and regulatorily implementable (a balancing criteria). However, Alternative 4 (In Situ Treatment, MNA, and ICs) was chosen over other alternatives because it was rated the best in the balancing criteria long-term effectiveness, reduction of TMV through treatment, short-term effectiveness, and had the lowest cost of all alternatives (Table 2-16). In particular, Alternative 4 has the best short-term effectiveness by achieving RAOs in the least time (51 years compared with 64 to 74 years) at the lowest present worth cost ($2.3 million compared to a range from $3.9 million to $5.5 million). In regards to modifying criteria, Alternative 4 has been accepted by the EPA, the UDEQ, and the community.

2.12.3 Deep TCE Plume

2.12.3.1 Description of the Selected Remedy

The selected remedy for the Deep TCE Plume is MNA and ICs. The ICs described in Section 2.9.4.2 will be maintained until RAOs are achieved. RA-O performance monitoring consisting of collection of groundwater samples for analysis of VOC concentrations will track compliance with RAOs. In situ treatment in the Shallow TCE Plume will also help limit additional migration of TCE from the Upper Zone into the Lower Zone.

In addition to RA-O performance monitoring, MNA will include additional groundwater monitoring and appropriate data analysis to assess natural attenuation processes and plume stability, and evaluate progress toward meeting RAOs. Groundwater samples will be collected and analyzed for TCE to assess sitewide groundwater conditions and trends. Frequency of sampling, analytical parameters, and the monitoring well network will be determined in the remedial design. The remedy will be considered complete when groundwater concentrations of COCs at or below the RGs are achieved and observed to be stable or decreasing with no likely rebound.

2.12.3.2 Summary of Estimated Remedy Costs

The present worth cost of Alternative 2 is approximately $2.8 million (Appendix B). As documented in Appendix B and in Table 2-17, the capital cost is estimated as $0.0 million. The O&M cost varies by year; the total O&M cost is estimated as $2.8 million. The present worth cost was calculated using a 1.1 percent discount rate and an estimated remedial timeframe of 67 years. The cost is an order-of-magnitude engineering estimate that is expected to be within +50 to -30 percent of the actual project cost, and was prepared based on available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements may occur based on new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, an ESD, or a ROD Amendment.

2.12.3.3 Expected Outcomes of Selected Remedy

Current ICs are expected to continue at OU 10. Cleanup levels for the selected remedy for the Deep TCE Plume are based on unlimited use and unrestricted exposure. Exposure will be controlled through ICs until TCE concentrations within groundwater are reduced to below 5 µg/L. Table 2-20 summarizes the unacceptable risks, the RAOs identified to address the risks, the remedy components intended to achieve the RAOs, the metrics that measure the remedial action progress, and the expected outcome of the remedy.

2.12.3.4 Summary of the Rationale for the Selected Remedy

Besides Alternative 1 (No Action), all alternatives considered met the threshold criteria of overall protection of human health and the environment and compliance with ARARs. Considering the balancing criteria, with the exception of short-term effectiveness, all alternatives meeting the threshold criteria have favorable ratings. However, Alternative 2 (MNA and ICs) was chosen over other alternatives because it was rated the best in implementability and short-term effectiveness (the alternative does not require any construction, resulting in less impact to the community), and had the lowest cost of all alternatives (Table 2-17). In particular, Alternative 2 has the best short-term effectiveness at the lowest present worth cost ($2.8 million compared to a range from $8.7 million to $36.2 million). Although Alternative 2 does not reduce the time to achieve RAOs compared to Alternative 1 (No Action), the improvement in time to achieve RAOs through Alternative 5 is insignificant (64 compared to 67 years). In regards to modifying criteria, Alternative 2 has been accepted by the EPA, the UDEQ, and the community. In summary, Alternative 2 was chosen because it was the least disruptive and least costly alternative, and the other alternatives did not offer any significant reductions in remedial timeframe.

2.13 Statutory Determinations

Under CERCLA Section 121 (as required by NCP Section 300.430[f][5][ii]), the EPA and USAF must jointly select a remedy that is protective of human health and the environment, complies with ARARs, is cost effective, and uses permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the TMV of hazardous wastes as a principal element and bias against offsite disposal of untreated wastes. The following sections discuss how the selected remedy meets these statutory requirements.

2.13.1 Protection of Human Health and the Environment

The selected remedies are protective of human health and the environment. ICs in the form of groundwater use restrictions will remain in place until RAOs are achieved, preventing human exposure.

For the PCE Plume and Shallow TCE Plume, the selected remedies incorporate ERD to reduce the mass of PCE and TCE in hot-spot areas to accelerate attainment of the protective ARAR MCLs of 5 µg/L to support site closeout. The selected remedy will not pose unacceptable short-term risks or cross-media impacts. Rigorous health and safety procedures and proper construction safety measures will mitigate the short-term risks associated with delivering in situ treatment amendments to the subsurface. Additionally, groundwater and soil gas sampling will occur following the implementation of the selected remedy to monitor gaseous byproduct concentrations. Vapor removal systems, such as an SVE system and/or a VRS, will be used if necessary to mitigate elevated levels of gaseous byproducts. Finally, the in situ treatment by natural processes treats the COCs in place, therefore minimizing the potential for cross-media impacts.

For the Deep TCE Plume, monitoring the groundwater will confirm that natural attenuation is reducing concentrations of TCE, cis-1,2-DCE, and trans-1,2-DCE below the protective ARAR MCLs of 5 µg/L , 70 µg/L, and 100 µg/L respectively, to support site closeout. The selected remedy does not disturb the contaminated media; therefore, implementation of the selected remedy will not pose unacceptable short-term risks nor will the selected remedy lead to cross-media impacts.

2.13.2 Compliance with ARARs

Remedial actions that occur completely on the CERCLA site (including within the off-Base area of contamination) are exempt from permitting but must comply with both Federal and State ARARs. ARARs are legally applicable or relevant and appropriate requirements, standards, criteria, or limitations of federal and state environmental laws and regulations.

ARARs fall into three categories—chemical-, location-, and action-specific. Chemical-specific ARARs are health-based or risk-management-based numbers that provide concentration limits for the occurrence of a chemical in the environment. Location-specific ARARs restrict activities in certain sensitive environments. Action-specific ARARs are activity- or technology-based, and typically control remedial activities that generate hazardous wastes (such as with those covered under RCRA). For example, construction activities that disturb the ground invoke stormwater action-specific ARARs. Criteria "to be considered" are non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. However, in many circumstances, to be considered criteria are considered along with ARARs.

Table 2-21 summarizes the ARARs and "to be considered" criteria for the selected remedies at the OU 10 plumes and describes how the selected remedies address each one. The selected remedies comply with the chemical-, location-, and action-specific ARARs. The implementation of the remedies is required to meet the substantive portions of these requirements and is exempt from administrative requirements such as permitting and notifications.

The State of Utah is authorized by the EPA to implement various regulatory programs, including water programs (e.g., Underground Injection Control and the National Pollutant Discharge Elimination System), the RCRA program, and various air programs. The State of Utah regulations for these programs have to be equal to or more stringent than the EPA's regulations for EPA to authorize the State of Utah to implement the programs. Because of this, the regulatory citations provided in Table 2-21 for these programs are to state regulations for which the state is authorized (has primacy), and not to the related federal regulations.

2.13.3 Cost Effectiveness

The selected remedies are cost effective and represent a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" (40 CFR 300.430[f][1][ii][D]). This determination was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfy the threshold criteria (i.e., is overall protective of human health and the environment and ARAR-compliant).

Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination—long-term effectiveness and permanence, reduction in TMV through treatment, and short-term effectiveness. Overall effectiveness was then compared to costs to determine cost effectiveness. The overall effectiveness of the selected remedies for the OU 10 plumes is discussed below and summarized in Table 2-22.

Additionally, the cost effectiveness of each remedial alternative was evaluated in this ROD for each plume. This was accomplished by calculating the reduction in the remedial timeframe of each alternative in comparison with the No Action Alternative (Alternative 1) and the cost above taking no action. Finally, a ratio of these two numbers was calculated to determine the reduction in remedial time per million dollars; generating a cost effectiveness ratio. Therefore, the more cost effective an alternative is, the greater the ratio. For example, the PCE Plume Alternative 6 present worth cost is $1.6 million and is estimated to reduce the remedial timeframe from 65 years to 32 years—a 33-year reduction. The Alternative 4 net present worth cost is $4.3 million and reduces the remedial timeframe by 20 years. Therefore, the cost-effectiveness ratio of Alternative 6 and 4 is 20.6 versus 4.7, respectively. Figures 2-9 and 2-10 graphically present these cost-effectiveness summaries for the PCE and Shallow TCE Plumes. No cost-effectiveness analysis was conducted for the Deep TCE Plume since there were no significant reductions in remedial timeframe between evaluated alternatives.

2.13.3.1 PCE Plume

The selected remedy (Alternative 6) is the most cost effective as compared to the other remedial alternatives because its costs are proportional to its overall effectiveness (40 CFR 300.430[f][1][ii][D]). Alternative 6 has the potential to achieve the RAOs and reduces TMV through treatment below the RGs without leaving long-term treatment residuals exceeding drinking water standards. Alternative 6 presents potential yet unlikely impacts to the community and to the environment through transportation of the treatment chemical and production of degradation byproducts, and degrades PCE faster than the other alternatives. Alternative 6 is the most cost-effective alternative with a present worth cost of $1.6 million as compared to the other alternatives that range from $2.8 million to $8.9 million, and it is estimated to reduce the remedial timeframe from 65 years to 32 years—a 33-year reduction (Figure 2-9). By demonstrating the greatest reduction in remedial time per million dollars, Figure 2-9 corroborates Alternative 6 as the most cost-effective alternative.

2.13.3.2 Shallow TCE Plume

The selected remedy (Alternative 4) is the most cost effective as compared to the other remedial alternatives. Alternative 4 has the potential to achieve the RAOs and reduces TMV through treatment below the RGs without leaving long-term treatment residuals exceeding drinking water standards. Alternative 4 presents potential yet unlikely impacts to the community and to the environment through transportation of the treatment chemical and production of degradation byproducts, and degrades TCE faster than the other alternatives (51 years, as compared to 64 to 74 years). Alternative 4 is the most cost-effective alternative with a present worth cost of $2.3 million, as compared to the other alternatives that range from $3.9 to $5.5 million (Figure 2-10). By demonstrating the greatest reduction in remedial time per million dollars, Figure 2-10 corroborates Alternative 4 as the most cost-effective alternative.

2.13.3.3 Deep TCE Plume

The selected remedy (Alternative 2) is the most cost effective as compared to the other remedial alternatives. Alternative 2 has the potential to achieve the RAOs and permanently reduce TCE concentrations below the MCL without leaving long-term residual contamination. Alternative 2 relies solely on natural attenuation mechanisms to reduce toxicity and mass of contaminants. Alternatives 3, 4, and 5 provide active treatment; however, there was little if any anticipated reduction in remedial timeframe between the alternatives. This indicates that active treatment does little to improve the time to achieve RAOs. Alternative 2 is the most cost-effective alternative with a present worth cost of $2.8 million, as compared to the other alternatives, which range from $8.7 million to $36.2 million.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The USAF has determined that the selected remedies for the OU 10 plumes represent the maximum extent to which permanent solutions and treatment technologies can be used in a practicable manner at the site. Of those alternatives that are protective of human health and the environment and comply with ARARs, the USAF has determined that the selected remedies provide the best balance of tradeoffs in terms of the five balancing criteria. In addition, the selected remedies consider the statutory preference for treatment as a principal element and bias against offsite treatment and disposal, and have state and community acceptance.

The selected remedies result in permanent removal of TCE- and PCE-contaminated groundwater through in situ treatment and natural attenuation in the Upper Zone. Natural attenuation mechanisms in the Lower Zone will degrade the Deep TCE Plume below RGs through a variety of degradation pathways supported by a diverse consortium of microbial groups. The selected remedies satisfy the criteria for long-term effectiveness by removing dissolved-phase groundwater COCs. Implementation of in situ injections may present some risks from the transportation and handling of the treatment chemicals, but these risks can be controlled using standard health and safety practices and are similar or lower to risks associated with other alternatives. For the PCE Plume and Shallow TCE plume, no implementability issues set the selected remedies apart from the other alternatives evaluated. The selected remedy for the Deep TCE Plume is more implementable and the most practicable compared to other evaluated alternatives.

2.13.5 Preference for Treatment as a Principal Element

The NCP establishes the expectation that treatment will be used to address the principal threats posed by a site wherever practicable (40 CFR 300.430[a][1][iii][A]). The selected remedies for the PCE Plume and Shallow TCE Plume satisfy the statutory preference for treatment as a principal element of the remedy. While the remedy for the Deep TCE Plume does not explicitly meet the statutory preference for treatment as a principal element, no active treatment remedies were seen to provide greater cost effectiveness or reduction in TMV.

Selected remedies for the PCE Plume and Shallow TCE Plume incorporate targeted in situ treatment to achieve ERD of PCE and TCE, respectively. ERD is a form of enhanced anaerobic bioremediation that uses highly biodegradable and soluble or emulsified organic electron donors to establish sulfate-reducing or methanogenic conditions to degrade chlorinated solvents, such as PCE and TCE into ethene and chloride ions.

The Deep TCE Plume remedy relies solely on natural attenuation mechanisms to reduce TMV of TCE. As discussed in preceding sections, implementation of active treatment technologies was seen to have little improvement in the reduction of TMV. An evaluation of natural attenuation mechanisms completed in the RI Report (CH2M HILL 2009a) and FS Report (CH2M HILL 2009b) indicated that different microbial degradation processes are occurring in the Lower Zone. It is likely that complete biodegradation of TCE and its daughter products is occurring through a variety of degradation pathways supported by a diverse consortium of microbial groups.

2.13.6 Five-Year Review Requirements

CERCLA Section 121(c) and NCP Section 300.430(f)(4)(ii) requires a Five-Year Review if the remedial action results in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure. A statutory review will be conducted within 5 years after initiation of remedial actions because the selected remedies will result in contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure. The objective of the Five-Year Review will be to verify that the remedies are, or will be, protective of human health and the environment. A Five-Year Review Report will be prepared to document the evaluation of the performance of the remedial systems. The report will recommend no changes to the selected remedies if the remedies are performing as expected and are continuing to protect human health and the environment. If the remedies are not performing as expected or are failing to protect human health and the environment, the Five-Year Review Report may recommend either operational changes, significant modifications of the remedies, or applications for ARAR waivers if necessary. If significant modifications of the remedies are required, including the identification of feasible innovative technologies, a ROD Amendment or an ESD may be necessary before significant modifications can be implemented. These Five-Year Reviews will continue until the selected remedies achieve concentrations of COCs that allow for unlimited use and unrestricted exposure.

2.14 Documentation of Significant Changes

After the RI and FS, concentrations of trans-1,2-DCE exceeding its MCL (100 µg/L) occurred in two monitoring wells within the Deep TCE Plume between 2009 and 2013. However, trans-1,2-DCE was not included as a COC in the OU 10 Proposed Plan (EA 2015a) because that document relied upon the risk assessment from the RI Report (CH2M HILL 2009a). In 2014, no monitoring wells contained concentrations of trans-1,2-DCE exceeding its MCL.

However, based on the revised risk assessment and the review of ARARs in this ROD, trans-1,2-DCE is included as a COC and will continue to be monitored.

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TABLE 2-1
Previous Site Investigations and Actions at Operable Unit 10
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Investigation	Contractor, Year	Summary
NAPA	MW 1995	Investigations in the area currently defined as OU 10 began in 1995 with the OU 9 NAPA. The objective of the NAPA was to identify potential contaminant release locations not investigated in the South Area Preliminary Assessment or other Hill AFB programs. The NAPA identified facilities, processes, systems, and practices that may have caused releases of chemicals to soil, surface water, and groundwater. The report identified 311 buildings or facilities of potential concern for further investigation. Each facility was categorized according to the potential threat (risk) to human health and the environment and was grouped into OU 9, which included all potential contaminant release locations not included under other Hill AFB IRP investigations. These facility categories consisted of three groups.
OU 9 North Area Site Inspection	MW 2000	The OU 9 North Area Site Inspection investigated the 311 facilities of potential concern identified in the NAPA to evaluate the presence of environmental contamination, to assess the potential human health and environmental risks, and to categorize the facilities accordingly. To meet those objectives, the inspection was organized into a three-phase approach. Phase I included collecting soil samples from suspected point sources of environmental contamination and collecting groundwater samples from areas where non-point sources were suspected. Phase II filled data gaps identified after completion of Phase I, attempted to locate sources of groundwater contamination detected during Phase I, and provided data necessary to assess human health and environmental risks. During Phase III of the OU 9 North Area Site Inspection, piezometers and monitoring wells were installed to evaluate groundwater flow direction and to confirm contamination detected during previous phases. The OU 9 North Area Site Inspection detected contamination in several portions of the OU 9 North Area. Groundwater samples from HydroPunch™ and monitoring wells in the 1200 Area identified groundwater contamination in the Upper Zone of the Shallow Aquifer system. In September 2000, based on the findings of the inspection, OU 9 was reorganized and divided into multiple OUs so that areas with similar remediation completion dates were grouped together. OU 10 was established during the reorganization to include the 1200 Area among various other areas, which would later be reorganized into other OUs. OU 10 was redefined to its current form in 2002.
OU 10 RI	CH2M HILL 2001–2009	The objective of the RI was to gather sufficient information to assess the nature, extent, fate, and transport of contamination; and evaluates the potential environmental and human health risks associated with the contaminants in order to support risk management decisions and the development of potential remedial alternatives. Soil, groundwater, and soil gas samples were collected to define the nature and extent of the contamination and assess potential risks to human health and the environment. Details regarding the nature and extent of contaminants are provided in Section 4 of the RI Report (CH2M HILL 2009a). Based on the analytical results, no unacceptable human health risks associated with surface and subsurface soil since the OWS and 4 cubic yards of contaminated soil were removed in 2003, pore water, surface water, or sediment were identified and no significant risks to ecological receptors were identified from exposure to site media. However, potential unacceptable risks were identified to hypothetical future residents from exposure to VOCs in groundwater if used as a potable water supply. The VOCs that exceeded their MCLs at that time in on- and off-Base groundwater monitoring wells were TCE, PCE, and cis-1,2-DCE.

TABLE 2-1
Previous Site Investigations and Actions at Operable Unit 10
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Investigation	Contractor, Year	Summary
OU 10 Treatability Study	CH2M HILL 2009	A treatability study was conducted to evaluate ERD and in situ chemical oxidation as applicable remedial technologies for treating groundwater contaminants of OU 10. This study provided valuable information on the performance and limitations of these two technologies in a dilute groundwater plume contained in a heterogeneous, unconsolidated alluvial aquifer. It was concluded that with improvement in the injectate delivery system and possibly improvement of ERD performance through bioaugmentation, the technologies could likely be optimized to form part of an effective remedy at OU 10 and similar sites at Hill AFB.
OU 10 FS	CH2M HILL 2009	Based on the human health risks identified in the RI Report, an FS was conducted to identify the RAOs for groundwater and potential treatment technologies to satisfy these RAOs. Remedial alternatives were separately developed for the PCE Plume, Shallow TCE Plume, and Deep TCE Plume. The OU 10 FS Report evaluated five alternatives for the PCE Plume and three alternatives for the Shallow TCE Plume. Five alternatives were developed in the OU 10 FS Report for the deep plume. Remedial alternative details are located in Section 3.4 of the FS Report (CH2M HILL 2009b).
OU 10 FS Supplement	EA 2014a	A supplement to the FS Report was prepared to evaluate additional remedial alternatives not evaluated in the OU 10 FS Report. One additional alternative was evaluated for the PCE and Shallow TCE Plumes. This supplement provided information required to support the OU 10 Proposed Plan (EA 2015a). As this information was considered in presenting the preferred remedial alternative for OU 10 and is not presented in the OU 10 FS Report, this supplement and associated attachments were included in the administrative file record.
OU 10 Proposed Plan	EA 2015a	The Proposed Plan summarized the RI and FS Reports and identifies the preferred remedial alternatives for OU 10. The proposed plan was issued to solicit public input on these preferred alternatives, which were in situ treatment, MNA, and ICs for the PCE and Shallow TCE Plumes and MNA and ICs for the Deep TCE Plume.

NOTES:
AFB = Air Force Base.
CPT = Cone penetration testing.
DCE = Dichloroethene.
EA = EA Engineering, Science, and Technology, Inc., PBC.
ERD = Enhanced reductive dechlorination.
FS = Feasibility Study.
IC = Institutional control.
IRP = Installation Restoration Program.
MCL = Maximum Contaminant Level.
MNA = Monitored natural attenuation.
MW = Montgomery Watson.
NAPA = North Area Preliminary Assessment.
OU = Operable unit.
OWS = Oil-water separator.
PCE = Tetrachloroethene.
RAO = Remedial action objective.
RI = Remedial Investigation.
TCE = Trichloroethene.
VOC = Volatile organic compound.

TABLE 2-2
Data Summary for Contaminants of Concern in Groundwater
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

	On-Base Maximum Concentration (µg/L)		**Off-Base Maximum Concentration (µg/L)**		**RGs[3] (µg/L)**
	Historical[1]	**Current[2]**	**Historical[1]**	**Current[2]**	
Upper Zone (Shallow Plumes)					
TCE	184	24	489	110	5
PCE	722	90	82	61	5
Lower Zone (Deep Plume)					
TCE	29	1.6	750	310	5
cis-1,2-DCE	41	13	170	140	70
trans-1,2-DCE	30	2.6	200	130	100

NOTES:
(1) Historical concentration data are from groundwater samples taken before 2013.
(2) Current concentration data are the maximum values from groundwater samples taken from each area between January 2013 and March 2014 (EA 2014b).
(3) RGs are EPA MCLs for each chemical in drinking water incorporated by Utah Rule R311-211-5 and are applicable for all remedial alternatives.

µg/L = Microgram(s) per liter.
DCE = Dichloroethene.
EPA = U.S. Environmental Protection Agency.
MCL = Maximum Contaminant Level.
PCE = Tetrachloroethene.
RG = Remediation goal.
TCE = Trichloroethene.

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TABLE 2-3
Data Summary for Contaminants of Concern in on-Base Soil Gas[1]
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

	On-Base Concentrations[2] (ppbv)		RGs[3] (ppbv)
	Minimum	**Maximum**	
TCE	<0.4	2,500	13
PCE	<0.4	1,400	210

NOTES:
(1) No COCs were identified for off-Base soil gas. Soil gas COCs represent potentially unacceptable risks to future receptors if new buildings are constructed over the TCE and PCE source areas. Indoor air data indicate there is no unacceptable risk to current receptors (CH2M HILL 2009b).
(2) Data are from samples collected from July 2008 to April 2009 (CH2M HILL 2009a).
(3) RGs are risk-based concentrations. Refer to Section 2.8 for additional details.

COC = Contaminant of concern.
PCE = Tetrachloroethene.
ppbv = Parts per billion by volume.
RG = Remediation goal.
TCE = Trichloroethene.

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TABLE 2-4
Summary of Lines of Evidence Supporting Natural Attenuation at Operable Unit 10
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Level 1		Level 2		Level 3	
Evidence	**References**	**Evidence**	**References**	**Evidence**	**References**
PCE Plume					
• Contaminant concentrations in historical source area are declining.	3	• Geochemical data indicate aerobic conditions that are supportive of aerobic cometabolism.	2, 3	• Detection of PCE in soil gas suggests volatilization is occurring.	3
• Thiessen-polygon analysis demonstrates dissolved mass reduction of approximately 29 percent from 2006 to 2013.	1	• Microbial-produced toluene monooxygenases have been identified in a number of OU 10 groundwater monitoring wells.	2, 3	• Off-Base phyto-degradation may be occurring (rhizodegradation), through uptake and transpiration.	3
		• First-order half-life calculated from the Thiessen-polygon analysis of approximately 14 years.		• Presence of toluene monooxygenases suggests bacteria capable of aerobic cometabolism are present and active.	2,3
Shallow TCE Plume					
• Thiessen-polygon analysis demonstrates mass reduction of approximately 25 percent from 2006 to 2013.	1	• Buscheck/Alcantar modeling indicates degradation half-life of 27 ±17 years.	2, 3	• Microcosm study using soils from the site showed that aerobic cometabolism is degrading TCE.	2, 3
		• First-order half-life calculated from the Thiessen-polygon analysis of approximately 15 years.	1		
		• Enzyme probes demonstrate that the enzymes responsible for aerobic cometabolism are active.	2, 3		
		• Geochemical data indicate predominantly aerobic and oxidizing conditions, conditions conducive for aerobic cometabolism.	2, 3		

TABLE 2-4
Summary of Lines of Evidence Supporting Natural Attenuation at Operable Unit 10
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Level 1		Level 2		Level 3	
Evidence	**References**	**Evidence**	**References**	**Evidence**	**References**
Deep TCE Plume					
• Thiessen-polygon analysis indicates that dissolved mass appears stable with a possible decreasing trend since 2010.	1	• Geochemical data indicate reducing conditions: the presence of reduced chemical species indicates, on average, an anaerobic, reducing environment; dissolved methane, suggestive of strongly reducing conditions, has been measured at some locations. • Compound-specific isotope analysis indicated between 46 and 92 percent degradation of original TCE to cis-1,2-DCE (eight sample locations).	2, 3	• Microbial deoxyribonucleic acid evidence suggests a microbial population with members capable of facilitating reductive dechlorination, producing cometabolic enzymes, and surviving under varied geochemical conditions. The microbial population is diverse and high in biomass and is likely acting as a consortium in the biodegradation of contaminants.	2,3
		• Degradation half-lives estimated from molar concentrations of TCE and daughter products (cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) ranged between 1 and 65 years. Half-lives estimated from CSIA data range between 4 and 60 years. The short half-lives indicate that reductive dechlorination occurs more rapidly in some portions of the aquifer.	2		

NOTES:
CSIA = Compound-specific isotope analysis.
DCE = Dichloroethene.
OU = Operable unit.
PCE = Tetrachloroethene.
TCE = Trichloroethene.

LINES OF EVIDENCE (EPA 1998):
Level 1: Historical data showing reductions in contaminant mass/concentrations over time.
Level 2: Hydrogeologic and geochemical data that provide indirect evidence of contaminant degradation and degradation rates.
Level 3: Data from field and microcosm studies to demonstrate the effectiveness of a particular natural attenuation process.

REFERENCES:
1 = Appendix A (Plume Stability Evaluation); 2 = CH2M HILL 2009a; 3 = CH2M HILL 2009b.

TABLE 2-5
Maximum Contaminant of Concern Concentrations in Relevant Operable Unit 10 Media
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Analyte	Groundwater(1) (μg/L)	Soil Gas(2) ($\mu g/m^3$)
cis-1,2-DCE	140	--
PCE	90	9,500
TCE	310	13,400
trans-1,2-DCE	130	--
VC	0.73	--

NOTES:
(1) Groundwater data from January 2013 through March 2014.
(2) Soil gas data from July 2008 to April 2009.

"--" = not a site-specific COC.
μg/L = Microgram(s) per liter.
$\mu g/m^3$ = Microgram(s) per cubic meter.
COC = Contaminant of concern.
DCE = Dichloroethene.
PCE = Tetrachloroethene.
TCE = Trichlorethene.
VC = Vinyl chloride.

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TABLE 2-6
Toxicity Factors
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Variable	Abbreviation	Units	cis-1,2-DCE	PCE	TCE	trans-1,2-DCE	VC
Oral Slope Factor – Cancer	Sfo	(mg/kg-day)-1	NA	2.1E-03	4.6E-02	NA	7.2E-01
Inhalation Unit Risk Factor – Cancer	IUR	(µg/m^3)-1	NA	2.6E-07	4.1E-06	NA	4.4E-06
Oral Reference Dose – Non-cancer	RfD	mg/kg-day	2.00E-03	6.0E-03	5.0E-04	2.00E-02	3.0E-03
Inhalation Reference Concentration – Non-cancer	RfC	µg/m^3	NA	4.0E-02	2.0E-03	NA	1.0E-01

NOTES:
µg/m^3 = Micrograms per cubic meter.
DCE = Dichloroethene.
mg/kg-day = milligrams per kilogram per day.
NA = Not applicable/none provided.
PCE = Tetrachloroethene.
TCE = Trichlorethene.
VC = Vinyl chloride.

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TABLE 2-7
Exposure Factors
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Variable	Abbreviation	Units	Child Resident	Adult Resident
Exposure duration	ED	year	6	20
Averaging time – cancer	ATc	days	25,550	25,550
Averaging time – non-cancer	ATnc	days	9,490	9,490
Exposure frequency	EFr	day/year	350	350
Tap water dermal exposure time	ETdermal	hour/event	0.54	0.71
Exposure time	ET	hour/day	24	24
Body weight	BW	kilograms	15	80
Water intake rate – child	IR	liter/day	0.78	2.5
Dermal event frequency	EVF	per day	1	1
Volatilization factor of Andelman	K	liter/cubic meter	0.5	0.5
Skin surface area	SA	square centimeters	6,378	20,900
Soil gas to indoor air attenuation factor(1)	AF	unitless	0.03	0.03

NOTE:
(1) Default soil gas-to-indoor air attenuation factor (0.03) (EPA 2013).

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TABLE 2-8
Risk Assessment Equations
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Exposure Scenario				Media, Pathways and Intake Routes			Concentration Factors					Exposure Factors and Results[(2)]					Toxicity Factors and Risk Results: Cancer					Toxicity Factors and Risk Results: Non-cancer				
On-Base Resident		On-Base Commercial/Industrial Worker		Primary Media	Pathways	Intake Routes	Measured Concentrations		Intermedia Partitioning Factors		Exposure Point Concentration			Receptor-specific Exposure Factors		Exposure Result	Exposure Result		Cancer Toxicity Factors		Cancer Results	Exposure Result		Non-cancer Toxicity Factors		Non-cancer Results
Current	Future	Current	Future																							
	X[(1)]			Groundwater	Tap Water Ingestion	ING	C_w			=	C_w	C_w	•	$\frac{IR \times EF \times ED}{BW \times AT}$	=	$Dose_{LifeAvg}$	$Dose_{LifeAvg}$	•	SF_o	=	ELCR	$Dose_{LifeAvg}$	•	$\frac{1}{RFD_o}$	=	HQ
	X[(1)]				Tap Water Volatilization	INH	C_w	•	K_{house}	=	C_{ia}	C_{ia}	•	$\frac{ET \times (24\ hr/day)^{-1} \times EF \times ED}{AT}$	=	$Conc_{LifeAvg}$	$Conc_{LifeAvg}$	•	IUR	=	ELCR	$Conc_{LifeAvg}$	•	$\frac{1}{RFC_i}$	=	HQ
	X[(1)]				Tap Water Dermal Contact	DER	C_w			=	C_w			$\frac{DA_{event} \times SA \times EF \times ED \times EVF}{BW \times AT}$	=	$Dose_{LifeAvg}$	$Dose_{LifeAvg}$	•	SF_o	=	ELCR	$Dose_{LifeAvg}$	•	$\frac{1}{RFDo}$	=	HQ
	X[(1)]		X[(3)]	Soil Vapor	Vapor Intrusion	INH	C_{sv}	•	AF	=	C_{ia}	C_{ia}	•	$\frac{ET \times (24\ hr/day)^{-1} \times EF \times ED}{AT}$	=	$Conc_{LifeAvg}$	$Conc_{LifeAvg}$	•	IUR	=	ELCR	$Conc_{LifeAvg}$	•	$\frac{1}{RFC_i}$	=	HQ

NOTES:
(1) Age-weighted ELCR = Σ Adult,Child ELCR
Age-weighted HQ = Σ Adult,Child HQ
The cancer calculations for TCE and VC were adjusted to account for mutagenicity consistent with EPA (2014c) guidance.
(2) The values of some exposure factors vary by receptor, age, and health endpoint (cancer versus non-cancer).
(3) Not quantified. Assumed to be bounded by the hypothetical future resident estimates.

AF = Soil Gas to Indoor Air Attenuation Factor.
AT = Averaging Time.
BW = Body Weight.
Cia = Concentration—Indoor Air.
ConcLifeAvg = Lifetime Averaged Concentration.
Csv = Concentration—Soil Vapor.
Cw = Concentration—Water.
DAevent = Dermally Absorbed Dose per Event (see Table 2-7 for equations and assumptions).
DER = Dermal Contact.
DoseLifeAvg = Lifetime Averaged Dose.
ED = Exposure Duration.
EF = Exposure Frequency.
ELCR = Excess Lifetime Cancer Risk.
ET = Exposure Time.
EVF = Event Frequency.
HQ = Hazard Quotient (non-cancer).
hr = Hours.
ING = Ingestion.
INH = Inhalation.
IR = Ingestion Rate.
IUR = Inhalation Unit Risk (cancer).
Khouse = Tap Water to Indoor Air Partitioning Factor.
RFCi = Inhalation Reference Concentration (non-cancer).
RFDo = Oral Reference Dose (non-cancer).
SA = Skin Surface Area.
SFo = Oral Slope Factor (cancer).
TCE = Trichlorethene.
VC = Vinyl chloride.

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TABLE 2-9
Dermally Absorbed Dose Calculations
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

DAevent (mg/cm^2-event) is calculated for organic compounds as follows :

$$If\ t_{event} \le t^*,\ then:\ DA_{event} = 2\ FA \times K_p \times C_w \sqrt{\frac{6\ \tau_{event} \times t_{event}}{\pi}}$$

$$If\ t_{event} > t^*,\ then:\ DA_{event} = FA \times K_p \times C_w \left[\frac{t_{event}}{1 + B} + 2\ \tau_{event}\left(\frac{1 + 3\ B + 3\ B^2}{(1 + B)^2}\right)\right]$$

Where:
DA_{event} = Absorbed dose per event (mg/cm-event)
FA = Fraction absorbed water (dimensionless)
Kp = Dermal permeability coefficient of compound in water (cm/hr)
Cw = Chemical concentration in water (mg/cm3) (see **Table 2-2**)
τ_{event} = Lag time per event (hr/event)
t_{event}= Event duration (hr/event) (see "Tap water Dermal Exposure Time" in **Table 2-4**)
t* = Time to reach steady-state (hr) = τ_{event}
B = Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (ve) (dimensionless)

Chemical	Kp	t*	τ_{event}	FA	B
cis-1,2-DCE	0.011	0.9	0.37	1	0.04
PCE	0.033	2.1	0.89	1	0.2
TCE	0.012	1.4	0.57	1	0.1
trans-1,2-DCE	0.011	0.9	0.37	1	0.04
VC	0.008	0.6	0.24	1	0.03

NOTES:
Values downloaded from US EPA online screening level calculator on December 11, 2014 (http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search) (EPA 2014b).

cm/hr = Centimeter(s) per hour.
DCE = Dichloroethene.
Hr = Hour(s).
PCE = Tetrachloroethene.
TCE = Trichlorethene.
VC = Vinyl chloride.

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TABLE 2-10
Risk Assessment Update Results
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Risk Endpoint	Analyte	Groundwater as Tap Water	Soil Gas to Future Hypothetical Residential Vapor Intrusion
Non-cancer Hazard Quotient	cis-1,2-DCE	2.7	--
	PCE	2	7
	TCE	**100**	**200**
	trans-1,2-DCE	0.3	--
	VC	0.01	--
	Hazard Index:	**100**	**200**
Excess Lifetime Cancer Risk	cis-1,2-DCE	NA	--
	PCE	8.E-06	3.E-05
	TCE	**6.E-04**	**8.E-04**
	trans-1,2-DCE	NA	--
	VC	4.E-05	--
	Cumulative ELCR:	**7.E-04**	**9.E-04**

NOTES:
"--" = not a site-specific COC
DCE = Dichloroethene.
ELCR = Excess lifetime cancer risk.
NA = Not applicable.
PCE = Tetrachloroethene.
TCE = Trichlorethene.
VC = Vinyl chloride.

Bold values indicate an ELCR > 1.E-04 or a Hazard Index > 1.

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TABLE 2-11
Derivation of Remediation Goals for Soil Gas
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Analyte	Carcinogenic Screening Level for Indoor Air at ELCR of 10^{-6} (1) (µg/m³)	Carcinogenic Screening Level for Indoor Air at ELCR of 10^{-5} (µg/m³)	Non-Carcinogenic Screening Level for Indoor Air at Hazard Index of 1 (1) (µg/m³)	Lower of the Two Values (2) (µg/m³)	Attenuation Factor (3)	Remediation Goal (µg/m³)	Molecular Weight (g/mol)	Remediation Goal (ppbv)
PCE	11	110	42	42	0.03	1,400	165.83	210
TCE	0.48	4.8	2.1	2.1		70	131.39	13

NOTES:
(1) Screening levels are for the residential exposure scenario and were obtained from the November 2014 Risk-Based Concentration table (EPA 2014c). EPA's current methodology for assessing inhalation risks (EPA 2009) does not include age-specific exposure factors. Thus, the non-cancer Regional Screening Levels are equivalent to those that would be calculated using and age-adjusted methodology.
(2) Lower of the carcinogenic screening level at 10^{-5} target risk or the non-carcinogenic screening level at target hazard index of 1.
(3) Default soil gas-to-indoor air attenuation factor (EPA 2013).

µg/m³ = Microgram(s) per cubic meter.
ELCR = Excess lifetime cancer risk.
g/mol = Gram(s) per mole.
ppbv = Parts per billion per volume.
PCE = Tetrachloroethene.
TCE = Trichlorethene.

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TABLE 2-12
Distinguishing Features of Remedial Alternatives for the PCE Plume
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Remedial Alternative Name	Alternative Description	Key ARARs	Long-Term Reliability of Remedy	Characteristics of Treatment Residuals	Estimated Time of Implementation	Estimated Remediation Time[(1)]	Estimated Capital, Annual O&M, and Total Present Worth Costs ($ million)[(1)]	Expected Outcomes
1: No Action	Alternative 1 consists of taking no further action. This alternative serves as a baseline for evaluating alternatives and is required by the NCP.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards	None	NA	NA	65 years	Capital = $0 O&M = $0 Total Present Worth = $0	Natural attenuation may return groundwater to potentially unrestricted use conditions, but there would be no verification of the restoration.
2: MNA and ICs	Alternative 2 includes MNA, continued groundwater monitoring, and groundwater use restrictions. The RAOs would be met in approximately 65 years.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards	Natural attenuation permanently reduces and removes contaminant mass, while ICs prevent exposure; minimal potential for remedy failure.	NA	NA	65 years	Capital = $0.04 O&M = $2.7 Total Present Worth = $2.8	Natural attenuation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs expected to prevent exposure to contamination until the RGs achieved.
3: PRB, MNA, and ICs	Alternative 3 is designed to reduce PCE concentrations and contain the plume by installing a 2.6-ft-wide trench filled with granular iron and sand to serve as a PRB. Natural attenuation should continue to reduce PCE concentrations over time. The RAOs would be met in approximately 50 years for the PCE Plume.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards	Moderate long-term effectiveness; potential for nitrate passivation; adequate long-term effectiveness requires replacement of zero-valent iron every 20 years.	No known toxic residuals anticipated from PRB treatment.	Approximately 1 year	50 years	Capital = $2.9 O&M = $6.0 Total Present Worth = $8.9	PRB and natural attenuation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs expected to prevent exposure to contamination until the RGs achieved.
4: Groundwater Extraction and Discharge, MNA, and ICs	Alternative 4 consists of installing one groundwater extraction well with the objective of preventing on-Base groundwater contamination from migrating off-Base, thereby reducing the remedial timeframe. The extracted, untreated groundwater would be discharged to the sanitary sewer for treatment at the local POTW, with sampling and analysis to verify that the discharged water meets POTW pretreatment requirements. The MNA component of this alternative consists of allowing portions of the plume downgradient of the extraction well to attenuate naturally. With an assumed extraction rate of 10 gallons per minute and the system running for 20 years, the RAOs would be met in approximately 45 years.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • 40 CFR Part 403–National Pretreatment Standards (33 USC § 1311–1330) • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards • UAC R317-8-8–Pretreatment	Generally reliable; however, the possibility of loss of performance due to biofouling and scaling exists.	No toxic residuals anticipated from groundwater extraction or biodegradation via aerobic cometabolism.	Approximately 1 year	45 years	Capital = $0.3 O&M = $4.0 Total Present Worth = $4.3	Groundwater extraction and natural attenuation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs expected to prevent exposure to contamination until the RGs achieved.

TABLE 2-12
Distinguishing Features of Remedial Alternatives for the PCE Plume
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Remedial Alternative Name	Alternative Description	Key ARARs	Long-Term Reliability of Remedy	Characteristics of Treatment Residuals	Estimated Time of Implementation	Estimated Remediation Time[(1)]	Estimated Capital, Annual O&M, and Total Present Worth Costs ($ million)[(1)]	Expected Outcomes
5: Phytoremediation, MNA, and ICs	Alternative 5 consists of phytoremediation, MNA, and ICs. Phytoremediation would be completed by planting 300 hybrid poplar trees above the off-Base portion of the PCE Plume. Remediation of the plume outside of this area would be by MNA. It is expected that the RAOs would be met in less than 65 years.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards	Natural attenuation and phytoremediation permanently reduce and remove contaminant mass, respectively, while ICs prevent exposure; minimal potential for remedy failure.	No known toxic residuals from phytoremediation or from biodegradation via aerobic cometabolism.	Approximately 1 year	<65 years	Capital = $0.3 O&M = $3.6 Total Present Worth = $3.9	Natural attenuation and phytoremediation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs expected to prevent exposure to contamination until the RGs are achieved. Phytoremediation system will also continue to capture greenhouse gases.
6: In Situ Treatment, MNA, and ICs	The objective of Alternative 6 is to reduce the remedial timeframe by incorporating targeted in situ treatment in addition to MNA and ICs. Carbon substrate injections for ERD would be completed in areas of high PCE concentrations on-Base (source area) and mid-plume (off-Base) to reduce the mass of PCE. Injections in the mid-plume area would be designed to create a target treatment zone approximately 15-30 ft bgs and about 200 wide and 28 ft long. The RAOs would be met in approximately 32 years for the PCE Plume.	• 40 CFR 144 and 146–Underground Injection Control Program: Criteria and Standards; as adopted by UAC R317-7 • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R315-101–Cleanup and Risk-based Closure Standards: RCRA, UST, and CERCLA Sites • UAC R317-7–Underground Injection Control Program	Selected technology has been shown to reduce TCE and PCE groundwater concentrations during the OU 10 Treatability Study (see Appendix E of the OU 10 FS Report).	Injection could result in temporary reductive dechlorination daughter products; as well as gaseous byproducts such as methane and vinyl chloride, and temporarily mobilize metals (e.g., ferrous iron, manganese, and arsenic). Accumulation of PCE daughter products (e.g., TCE, cis-1,2-DCE, and VC) is likely to be temporary and daughter products will attenuate. Concentrations of methane and metals will decline once conditions return to aerobic conditions after treatment ceases.	Approximately 1 year	32 years	Capital = $0.9 O&M = $0.7 Total Present Worth = $1.6	In situ treatment would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs are expected to prevent exposure to contamination until RGs are achieved. Risks caused by potential gaseous byproducts created as a result of substrate injections will be mitigated via SVE and/or VRSs. Mobilized metals are expected to become immobile once they migrate outside the treatment zone or after reducing conditions created by substrate dissipate.

NOTES:
[(1)] Estimated remedial timeframes and costs are presented in the OU 10 FS Report (CH2M HILL 2009b) and the OU 10 FS Supplement (EA 2014a). Estimated costs are within a -30 to +50 percent accuracy range.

ARAR = Applicable or Relevant and Appropriate Requirement.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
CFR = Code of Federal Regulations.
ERD = Enhanced reductive dechlorination.
FS = Feasibility Study.
ft = Feet; foot.
IC = Institutional control.
MCL = Maximum Contaminant Level.
MNA = Monitored natural attenuation.
NA = Not applicable.
NCP = National Oil and Hazardous Substances Pollution Contingency Plan.
O&M = Operation and maintenance.
OU = Operable unit.
PCE = Tetrachloroethene.
POTW = Publicly owned treatment works.
PRB = Permeable reactive barrier.
RAO = Remedial action objective.
RCRA = Resource Conservation and Recovery Act.
RG = Remediation goal.
SVE = Soil vapor extraction.
UAC = Utah Administrative Code.
USC = United States Code.
UST = Underground storage tank.
VRS = Vapor removal system.

TABLE 2-13
Distinguishing Features of Remedial Alternatives for the Shallow TCE Plume
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Remedial Alternative Name	Alternative Description	Key ARARs	Long-Term Reliability of Remedy	Characteristics of Treatment Residuals	Estimated Time of Implementation	Estimated Remediation Time[1]	Estimated Capital, Annual O&M, and Total Present Worth Costs ($ million)[1]	Expected Outcomes
1: No Action	Alternative 1 consists of taking no further action. This alternative serves as a baseline for evaluating Alternatives and is required by the NCP.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards	None	NA	NA	74 years	Capital = $0 O&M = $0 Total Present Worth = $0	Natural attenuation may return groundwater to potentially unrestricted use conditions, but there would be no verification of the restoration.
2: MNA, and ICs	Alternative 2 includes MNA and continued groundwater use restrictions. The RAOs would be met in approximately 74 years.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards	Natural attenuation permanently reduces and removes contaminant mass, while ICs prevent exposure; minimal potential for remedy failure.	NA	NA	74 years	Capital = $0.1 O&M = $3.8 Total Present Worth = $3.9	Natural attenuation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs expected to prevent exposure to contamination until the RGs achieved.
3: Groundwater Extraction and Discharge, MNA, and ICs	Alternative 3 consists of installing three groundwater extraction and discharge wells designed to reduce the remediation timeframe by reducing contaminant mass from the on-Base portions of the Shallow TCE Plume. The extracted, untreated groundwater would be discharged to the sanitary sewer for treatment at the local POTW, with sampling and analysis to verify that the discharged water meets POTW pretreatment requirements. The MNA component of this Alternative consists of allowing portions of the plume to attenuate naturally. With a combined extraction rate of 25 gallons per minute and the systems running for 5 years, the RAOs would be met in approximately 64 years.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • 40 CFR Part 403–National Pretreatment Standards (33 USC § 1311–1330) • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards • UAC R317-8-8–Pretreatment	Generally reliable; however, the possibility of loss of performance due to biofouling and scaling exists.	No toxic residuals anticipated from groundwater extraction or biodegradation via aerobic cometabolism.	Approximately 1 year	64 years	Capital = $0.9 O&M = $4.6 Total Present Worth = $5.5	Groundwater extraction and natural attenuation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs expected to prevent exposure to contamination until the RGs achieved.

TABLE 2-13
Distinguishing Features of Remedial Alternatives for the Shallow TCE Plume
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Remedial Alternative Name	Alternative Description	Key ARARs	Long-Term Reliability of Remedy	Characteristics of Treatment Residuals	Estimated Time of Implementation	Estimated Remediation Time[1]	Estimated Capital, Annual O&M, and Total Present Worth Costs ($ million)[1]	Expected Outcomes
4: In situ Treatment, MNA, and ICs	The objective of Alternative 4 is to reduce the remedial timeframe by incorporating targeted in situ treatment at areas of high TCE concentrations. To enhance biodegradation, carbon substrate injections would be completed at the core of the TCE Plume using two corridors of injection wells. Injection wells would be installed in side streets along 200 West and 600 North in the City of Clearfield. The RAOs would be met in approximately 51 years for the Shallow TCE Plume.	• 40 CFR 144 and 146–Underground Injection Control Program: Criteria and Standards; as adopted by UAC R317-7 • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R315-101–Cleanup and Risk-based Closure Standards: RCRA, UST, and CERCLA Sites • UAC R317-7–Underground Injection Control Program	Selected technology has been shown to reduce TCE and PCE groundwater concentrations during the OU 10 Treatability Study (see Appendix E of the OU 10 FS Report).	Injection could result in temporary reductive dechlorination daughter products; as well as gaseous byproducts, such as methane and vinyl chloride, and temporarily mobilize metals (e.g., ferrous iron, manganese, and arsenic). Accumulation of TCE daughter products (e.g., cis-1,2-DCE and VC) is likely to be temporary and daughter products will attenuate. Concentrations of methane and metals will decline once conditions return to aerobic conditions after treatment ceases.	Approximately 1 year	51 years	Capital = $0.9 O&M = $1.4 Total Present Worth = $2.3	In situ treatment and MNA would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs are expected to prevent exposure to contamination until RGs achieved. Risks caused by potential gaseous byproducts created as a result of substrate injections will be mitigated via SVE and/or VRSs. Mobilized metals are expected to become immobile once they migrate outside treatment zone or after reducing conditions created by substrate dissipate.

NOTES:
[1] Estimated remedial timeframes and costs are presented in the OU 10 FS Report (CH2M HILL 2009b) and the OU 10 FS Supplement (EA 2014a). Estimated costs are within a -30 to +50 percent accuracy range.

ARAR = Applicable or Relevant and Appropriate Requirement.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
CFR = Code of Federal Regulations.
DCE = Dichloroethene.
EISB = Enhanced in situ bioremediation.
ERD = Enhanced reductive dechlorination.
FS = Feasibility Study.
ft = Feet(foot).
IC = Institutional control.
MCL = Maximum Contaminant Level.
MNA = Monitored natural attenuation.
NA = Not applicable.
NCP = National Oil and Hazardous Substances Pollution Contingency Plan.
O&M = Operation and maintenance.
OU = Operable Unit.
PCE = Tetrachloroethene.
POTW = Publicly owned treatment works.
PRB = Permeable reactive barrier.
RAO = Remedial action objective.
RCRA = Resource Conservation and Recovery Act.
RG = Remediation goal.
SVE = Soil vapor extraction.
UAC = Utah Administrative Code.
USC = United States Code.
UST = Underground storage tank.
VC = Vinyl chloride.
VRS = Vapor removal system.

TABLE 2-14
Distinguishing Features of Remedial Alternatives for the Deep TCE Plume
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Remedial Alternative Name	Alternative Description	Key ARARs	Long-Term Reliability of Remedy	Characteristics of Treatment Residuals	Estimated Time of Implementation	Estimated Remediation Time[(1)]	Estimated Capital, Annual O&M, and Total Present Worth Costs ($ million)[(1)]	Expected Outcomes
1: No Action	Alternative 1 consists of taking no further action. This alternative serves as a baseline for evaluating Alternatives and is required by the NCP.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards	None.	NA	NA	67 years	Capital = $0 O&M = $0 Total Present Worth = $0	Natural attenuation may return groundwater to potentially unrestricted use conditions, but there would be no verification of the restoration.
2: MNA, and ICs	Alternative 2 includes MNA and ICs. ICs would be maintained. Natural attenuation in the Shallow TCE Plume would also help limit additional potential migration of TCE from the Upper Zone into the Lower Zone. The RAOs for this alternative would be met in approximately 67 years.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards	Natural attenuation permanently reduces and removes contaminant mass, while ICs prevent exposure; minimal potential for remedy failure.	NA	NA	67 years	Capital = $0 O&M = $2.8 Total Present Worth = $2.8	Natural attenuation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs expected to prevent exposure to contamination until the RGs achieved.
3: ERD, MNA, and ICs	Alternative 3 consists of in situ bioremediation through the installation of 67 injection wells that would deliver a biological substrate to create a 2,000-ft-wide biological barrier at the toe of the Deep TCE Plume. Natural attenuation of the TCE Plume would continue to be monitored and the progress toward meeting the RAOs evaluated. The estimated remedial timeframe for this alternative is also 67 years.	• 40 CFR 144 and 146–Underground Injection Control Program: Criteria and Standards; as adopted by UAC R317-7 • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R315-101–Cleanup and Risk-based Closure Standards: RCRA, UST, and CERCLA Sites • UAC R317-7–Underground Injection Control Program	Moderate long-term effectiveness; selected technology is reliable as shown by the OU 10 Treatability Study (see Appendix E of the OU 10 FS Report).	Injection could result in temporary reductive dechlorination daughter products (e.g., cis-1,2-DCE and VC); as well as gaseous byproducts (methane) and temporarily mobilize metals (e.g., ferrous iron, manganese, and arsenic).	Approximately 1 year	67 years	Capital = $20.6 O&M = $15.6 Total Present Worth = $36.2	Enhanced bioremediation and natural attenuation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs are expected to prevent exposure to contamination until the RGs achieved.
4: One-Well HC, MNA, and ICs	Alternative 4 is intended to reduce plume migration by installing one extraction well at the toe of the Deep TCE Plume. The extracted, untreated groundwater would be discharged to the sanitary sewer for treatment at the local POTW, with sampling and analysis to verify that the discharged water meets POTW pretreatment requirements. Attenuation of the TCE Plume would continue to be monitored and the progress toward meeting the	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • 40 CFR Part 403–National Pretreatment Standards (33 USC § 1311–1330) • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites	HC is a proven technology and is therefore considered reliable.	NA	Approximately 1 year	67 years	Capital = $2.0 O&M = $6.6 Total Present Worth = $8.7	Groundwater extraction and natural attenuation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs expected to prevent exposure to contamination until the RGs achieved.

TABLE 2-14
Distinguishing Features of Remedial Alternatives for the Deep TCE Plume
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Remedial Alternative Name	Alternative Description	Key ARARs	Long-Term Reliability of Remedy	Characteristics of Treatment Residuals	Estimated Time of Implementation	Estimated Remediation Time[1]	Estimated Capital, Annual O&M, and Total Present Worth Costs ($ million)[1]	Expected Outcomes
	RAOs evaluated. With an assumed extraction rate of 100 gallons per minute and the system running for 30 years, the RAOs would also be met in 67 years.	• UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards • UAC R317-8-8–Pretreatment						
5: Three-Well HC, MNA, and ICs	The objective of Alternative 5 is to enhance the containment and restoration timeframe evaluated in Alternative 4 by installing three extraction wells. The extracted, untreated groundwater would be discharged to the sanitary sewer for treatment at the local POTW, with sampling and analysis to ensure that the discharged water meets POTW pretreatment requirements. Attenuation of the TCE Plume would continue to be monitored and the progress toward meeting the RAOs evaluated. With a combined extraction rate of 210 gallons per minute and the systems running for 30 years, the RAOs would be met in 64 years.	• 40 CFR 141 Subpart G–National Primary Drinking Water Regulations: MCLs and Maximum Residual Disinfectant Levels • 40 CFR Part 403–National Pretreatment Standards (33 USC § 1311–1330) • UAC R311-211–Corrective Actions Cleanup Standards Policy—UST and CERCLA Sites • UAC R309-200-5–Monitoring and Water Quality: Drinking Water Standards • UAC R317-8-8–Pretreatment	HC is a proven technology and is therefore considered reliable.	NA	Approximately 1 year	64 years	Capital = $2.8 O&M = $8.6 Total Present Worth = $11.4	Groundwater extraction and natural attenuation would restore groundwater to potentially unrestricted use conditions within a reasonable timeframe. ICs expected to prevent exposure to contamination until the RGs achieved.

NOTES:
[1] Estimated remedial timeframes and costs are presented in the OU 10 FS Report (CH2M HILL 2009b) and the OU 10 FS Supplement (EA 2014a). Estimated costs are within a -30 to +50 percent accuracy range.

ARAR = Applicable or Relevant and Appropriate Requirement.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
CFR = Code of Federal Regulations.
DCE = Dichloroethene.
ERD = Enhanced reductive dechlorination.
FS = Feasibility Study.
Ft = Feet; foot.
HC = Hydraulic containment.
IC = Institutional control.
MCL = Maximum Contaminant Level.
MNA = Monitored natural attenuation.
NA = Not applicable.
NCP = National Oil and Hazardous Substances Pollution Contingency Plan.
O&M = Operation and maintenance.
OU = Operable Unit.
PCE = Tetrachloroethene.
POTW = Publicly owned treatment works.
PRB = Permeable reactive barrier.
RAO = Remedial action objective.
RCRA = Resource Conservation and Recovery Act.
RG = Remediation goal.
SVE = Soil vapor extraction.
UAC = Utah Administrative Code.
USC = United States Code.
UST = Underground storage tank.
VC = Vinyl chloride.
VRS = Vapor removal system.

TABLE 2-15
Comparative Analysis of PCE Plume Remedial Alternatives
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Criterion	Alternative 1: No Action	Alternative 2: MNA, ICs	Alternative 3: PRB, MNA, ICs	Alternative 4: GED, MNA, ICs	Alternative 5: Phyto, MNA, ICs	Alternative 6: In Situ, MNA, ICs
Overall Protection of Human Health and the Environment	Not Protective	Protective	Protective	Protective	Protective	Protective
Compliance with ARARs	Not Evaluated	Compliant	Compliant	Compliant	Compliant	Compliant
Long-Term Effectiveness	Not Evaluated	Moderate	Moderate	Moderate	Moderate	Good
Reduction of TMV	Not Evaluated	Potentially Adequate	Adequate	Adequate	Adequate	Good
Short-Term Effectiveness	Not Evaluated	Good	Moderate	Moderate	Moderate	Good
Implementability	Not Evaluated	Implementable	Implementable	Implementable	Implementable	Implementable
Total Life-Cycle Present Worth Cost[(1)]						
Capital	$0	$41,000	$2,867,000	$335,000	$291,000	$895,000
O&M	$0	$2,717,000	$6,045,000	$3,977,000	$3,627,000	$675,000
Present Worth Cost	$0	$2,757,000	$8,911,000	$4,311,000	$3,918,000	$1,570,000
Remedial Timeframe[(2)]	65 years	65 years	50 years	45 years	<65 years	32 years
Regulatory Acceptance	Not Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Community Acceptance	Not Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

NOTES:
(1) Costs for Alternatives 1 through 5 were obtained from the OU 10 FS Report (CH2M HILL 2009b). Costs for Alternative 6 are presented in Appendix B. Estimated costs are within a -30 to +50 percent accuracy range.
(2) Remedial timeframes for Alternatives 1 through 5 correspond to results from the 2009 groundwater model presented in the OU 10 FS Report (CH2M HILL 2009b). The remedial timeframe for Alternative 6 is documented in the OU 10 Feasibility Study Supplement (EA 2014a).

ARAR = Applicable or Relevant and Appropriate Requirement.
EA = EA Engineering, Science, and Technology, Inc., PBC
FS = Feasibility Study.
GED = Groundwater extraction and discharge.
IC = Institutional control.
MNA = Monitored natural attenuation.
O&M = Operation and maintenance.
OU = Operable Unit.
PRB = Permeable reactive barrier.
TMV = Toxicity, mobility, or volume.

TABLE 2-16
Comparative Analysis of Shallow TCE Plume Remedial Alternatives
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Criterion	Alternative 1: No Action	Alternative 2: MNA, ICs	Alternative 3: GED, MNA, ICs	Alternative 4: In Situ, MNA, ICs
Overall Protection of Human Health and the Environment	Not Protective	Protective	Protective	Protective
Compliance with ARARs	Not Evaluated	Compliant	Compliant	Compliant
Long-Term Effectiveness	Not Evaluated	Moderate	Moderate	Good
Reduction of TMV	Not Evaluated	Adequate	Adequate	Good
Short-Term Effectiveness	Not Evaluated	Good	Moderate	Good
Implementability	Not Evaluated	Implementable	Implementable	Implementable
Total Life-Cycle Present Worth Cost[1]				
Capital	$0	$69,000	$865,000	$946,000
O&M	$0	$3,793,000	$4,594,000	$1,370,000
Present Worth Cost	$0	$3,861,000	$5,458,000	$2,316,000
Remedial Timeframe[2]	74 years	74 years	64 years	51 years
Regulatory Acceptance	Not Acceptable	Acceptable	Acceptable	Acceptable
Community Acceptance	Not Acceptable	Acceptable	Acceptable	Acceptable

NOTES:
[1] Costs for Alternatives 1 through 3 were obtained from the OU 10 FS Report (CH2M HILL 2009b). Costs for Alternative 4 are presented in Appendix B. Estimated costs are within a -30 to +50 percent accuracy range.
[2] Remedial timeframes for Alternatives 1 through 3 correspond to results from the 2009 groundwater model presented in the OU 10 FS Report (CH2M HILL 2009b). The remedial timeframe for Alternative 4 is documented in the OU 10 FS Supplement (EA 2014a).

ARAR = Applicable or Relevant and Appropriate Requirement.
EA = EA Engineering, Science, and Technology, Inc., PBC
FS = Feasibility Study.
GED = Groundwater extraction and discharge.
IC = Institutional control.
MNA = Monitored natural attenuation.
O&M = Operation and maintenance.
OU = Operable Unit.
TMV = Toxicity, mobility, or volume.

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TABLE 2-17
Comparative Analysis of Deep TCE Plume Remedial Alternatives
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Criterion	Alternative 1: No Action	Alternative 2: MNA, ICs	Alternative 3: EISB, MNA, ICs	Alternative 4: 1-Well HC, MNA, ICs	Alternative 5: 3-Well HC, MNA, ICs
Overall Protection of Human Health and the Environment	Not Protective	Protective	Protective	Protective	Protective
Compliance with ARARs	Not Evaluated	Compliant	Compliant	Compliant	Compliant
Long-Term Effectiveness	Not Evaluated	Moderate	Moderate	Moderate	Moderate
Reduction of TMV	Not Evaluated	Moderate	Moderate	Moderate	Moderate
Short-Term Effectiveness	Not Evaluated	Good	Moderate	Moderate	Moderate
Implementability	Not Evaluated	Implementable	Implementable	Implementable	Implementable
Total Life-Cycle Present Worth Cost[1]					
Capital	$0	$0	$20,552,000	$2,022,000	$2,825,000
O&M	$0	$2,750,000	$15,630,000	$6,644,000	$8,576,000
Present Worth Cost	$0	$2,750,000	$36,182,000	$8,666,000	$11,401,000
Remedial Timeframe[2]	67 years	67 years	67 years	67 years	64 years
Regulatory Acceptance	Not Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Community Acceptance	Not Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

NOTES:
[1] Costs for Alternatives 1 through 5 were obtained from the OU 10 FS Report (CH2M HILL 2009b). Costs for Alternative 2 are presented in Appendix B. Estimated costs are within -30 to +50 percent accuracy range.
[2] Remedial timeframes for Alternatives 1 through 5 correspond to results from the 2009 groundwater model presented in the OU 10 FS Report (CH2M HILL 2009b).

ARAR = Applicable or Relevant and Appropriate Requirement.
EISB = Enhanced in situ bioremediation.
FS = Feasibility Study.
GED = Groundwater extraction and discharge.
HC = Hydraulic containment.
IC = Institutional control.
MNA = Monitored natural attenuation.
O&M = Operation and maintenance.
OU = Operable Unit.
TMV = Toxicity, mobility, or volume.

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TABLE 2-18
Expected Outcomes of the Selected Remedy – PCE Plume
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Risk	Remedial Action Objective	Remedy Component	Metric	Expected Outcome
Further migration of contaminated groundwater	Prevent further horizontal and vertical migration of contaminated groundwater.	MNA	Implement MNA until COC groundwater concentrations are at or below their respective EPA MCLs and to verify plume stability.	Gain additional evidence supporting plume stability/ reduction and reduce plume extent.
		In Situ Treatment	Inject carbon substrate to reduce the remedial timeframe of PCE contaminated groundwater.	
Future industrial/ construction worker and residential exposure to PCE in groundwater (on-Base and off-Base) and on-Base soil gas	Prevent direct human exposure to contaminated groundwater.	ICs	Maintain ICs to prevent intrusive activities and industrial or residential use, indefinitely as COC groundwater concentrations remain above their respective EPA MCLs.	Maintain current restricted groundwater use.
	Prevent unacceptable human health risks posed by the potential future inhalation of contaminant vapors in on-Base indoor air.	ICs	Maintain current ICs related to evaluation and mitigation of vapor intrusion risk prior to construction of new buildings in the on-Base area of OU 10.	Prevention of unacceptable human health risks due to potential future vapor intrusion in on-Base area.
	Prevent further horizontal and vertical migration of contaminated groundwater.	In Situ Treatment	Inject carbon substrate to reduce the remedial timeframe of PCE contaminated groundwater.	Unlimited use and unrestricted exposure.
	Restore groundwater to its expected beneficial use within a reasonable timeframe. Given the hydrogeologic setting and current available remedial technologies, restoration timeframes of 50 to 100 years are anticipated and considered reasonable.	MNA	Implement MNA until COC concentrations in groundwater are at or below their respective EPA MCL and to verify plume stability.	

NOTES:
COC = Contaminant of concern.
EPA = U.S. Environmental Protection Agency.
IC = Institutional control.
MCL = Maximum Contaminant Level.
MNA = Monitored natural attenuation.
OU = Operable Unit.
PCE = Tetrachloroethene.

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TABLE 2-19
Expected Outcomes of the Selected Remedy – Shallow TCE Plume
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Risk	Remedial Action Objective	Remedy Component	Metric	Expected Outcome
Further migration of contaminated groundwater	Prevent further horizontal and vertical migration of contaminated groundwater.	MNA	Implement MNA until COC groundwater concentrations are at or below their respective EPA MCLs and to verify plume stability.	Gain additional evidence supporting plume stability/ reduction and reduce plume extent.
		In Situ Treatment	Inject carbon substrate to reduce the remedial timeframe of TCE-contaminated groundwater.	
Future industrial/ construction worker and residential exposure to TCE in groundwater (on-Base and off-Base) and on-Base soil gas	Prevent direct human exposure to contaminated groundwater.	ICs	Maintain ICs to prevent intrusive activities and industrial or residential use, indefinitely as COC concentrations in groundwater remain above their respective EPA MCL.	Maintain current restricted groundwater use.
	Prevent unacceptable human health risks posed by the potential future inhalation of contaminant vapors in on-Base indoor air.	ICs	Maintain current ICs related to evaluation and mitigation of vapor intrusion risk prior to construction of new buildings in the on-Base area of OU 10.	Prevention of unacceptable human health risks due to potential future vapor intrusion in on-Base area.
	Prevent further horizontal and vertical migration of contaminated groundwater. Restore groundwater to its expected beneficial use within a reasonable timeframe. Given the hydrogeologic setting and current available remedial technologies, restoration timeframes of 50 to 100 years are anticipated and considered reasonable.	In Situ Treatment	Inject carbon substrate to reduce the remedial timeframe of TCE-contaminated groundwater.	Unlimited use and unrestricted exposure.
		MNA	Implement MNA/RA-O performance monitoring until COC concentrations in groundwater are at or below their respective EPA MCL and to verify plume stability.	

NOTES:
COC = Contaminant of concern.
EPA = U.S. Environmental Protection Agency.
IC = Institutional control.
MCL = Maximum Contaminant Level.
MNA = Monitored natural attenuation.
OU = Operable Unit.
RA-O = Remedial action operations.
PCE = Tetrachloroethene.
TCE = Trichloroethene.

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TABLE 2-20
Expected Outcomes of the Selected Remedy – Deep TCE Plume
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

<table>
<tr><th>Risk</th><th>RAO</th><th>Remedy Component</th><th>Metric</th><th>Expected Outcome</th></tr>
<tr><td>Further migration of contaminated groundwater</td><td>Prevent further horizontal and vertical migration of contaminated groundwater.</td><td>MNA</td><td>Implement MNA until COC groundwater concentrations are at or below their respective EPA MCLs and to verify plume stability.</td><td>Additional evidence supporting plume stability and reduction.</td></tr>
<tr><td rowspan="3">Future industrial/ construction worker and residential exposure to TCE in groundwater</td><td>Prevent direct human exposure to contaminated groundwater.</td><td>ICs</td><td>Maintain ICs to prevent intrusive activities and industrial or residential use, indefinitely as COCs concentrations in groundwater remain above their respective EPA MCL.</td><td>Current restricted groundwater use.</td></tr>
<tr><td>Prevent further horizontal and vertical migration of contaminated groundwater.</td><td>MNA</td><td>Implement MNA until COCs concentrations in groundwater are at or below their respective EPA MCL and to verify plume stability.</td><td rowspan="2">Unlimited use and unrestricted exposure.</td></tr>
<tr><td>Restore groundwater to its expected beneficial use within a reasonable timeframe. Given the hydrogeologic setting and current available remedial technologies, restoration timeframes of 50 to 100 years are anticipated and considered reasonable.</td><td>ICs</td><td>Maintain ICs to prevent intrusive activities and industrial or residential use of contaminated groundwater while COC concentrations remain above their respective EPA MCL.</td></tr>
</table>

NOTES:
COC = Contaminant of concern.
EPA = U.S. Environmental Protection Agency.
IC = Institutional control.
MCL = Maximum Contaminant Level.
MNA = Monitored natural attenuation.
RAO = Remedial action objective.
TCE = Trichloroethene.

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TABLE 2-21
Summary of Applicable or Relevant and Appropriate Requirements for the Selected Remedies
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Type	Authority	Medium	Requirement	Applicable Remedy: PCE Plume	Applicable Remedy: Shallow TCE Plume	Applicable Remedy: Deep TCE Plume	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Chemical-specific	Federal Regulatory Requirement	Groundwater	Federal Safe Drinking Water MCLs; 40 CFR 141 Subpart G	X	X	X	Relevant and Appropriate	Establishes health-based standards (MCLs) for specific organic and inorganic substances to protect drinking water quality. The COCs and associated MCLs are: TCE = 0.005 mg/L, PCE = 0.005 mg/L, cis-1,2-DCE = 0.07 mg/L, and trans-1,2-DCE = 0.1 mg/L	The selected remedies will comply by reduction of contaminants through treatment or natural attenuation that will allow the MCLs to be met.
Chemical-specific	State Regulatory Requirement	Groundwater	Monitoring and Water Quality; Drinking Water – UAC R309-200-5, 6	X	X	X	Relevant and Appropriate	Establishes primary and secondary MCLs for inorganic and organic chemicals including COCs. The COCs and associated MCLs are: TCE = 0.005 mg/L, PCE = 0.005 mg/L, cis-1,2-DCE = 0.07 mg/L, and trans-1,2-DCE = 0.1 mg/L.	The selected remedies will comply by reduction of contaminants through treatment or natural attenuation that will allow the MCLs to be met.
Chemical-specific	State Regulatory Requirement	Groundwater	Environmental Quality and Water Quality; Groundwater Protection – UAC R317-6	X	X	X	Applicable	Establishes ground water quality standards (R317-6-2), ground water classes (R317-6-3), and ground water class protection levels (R317-6-4). Ground water quality standards (R317-6-2) are applicable corrective action cleanup levels for contaminated ground water under R317-6-6.15F. The standards are the same as primary drinking water standards for the contaminants of concern at this site (i.e., MCLs). Alternate corrective action concentration limits can be established pursuant to R317-6-6.15. Groundwater class protection levels (R317-6-4) are not intended to be used as ARARs under CERCLA.	The selected remedies will comply by reduction of contaminants through treatment or natural attenuation that will allow the MCLs to be met.
Action-specific	State Regulatory Requirement	Groundwater	Cleanup and Risk-Based Closure Standards: RCRA, UST, and CERCLA Sites – UAC R315-101	X	X	X	Applicable	UAC R315-101 establishes requirements to support risk-based cleanup and closure standards at sites for which remediation or removal of hazardous constituents to background levels will not be achieved. The procedures in this rule also provide for continued management of sites for which minimal risk-based standards cannot be met. Requires removal or control of the source (R315-101-2) and no degradation beyond existing contaminant levels. R315-101-3 (Principle of Non-Degradation) requires monitoring of the site and triggers corrective action if concentrations increase. R315-101-5 requires an evaluation of risk to be performed. R315-101-6 requires a site management plan that evaluates and proposes remedies or no further action based on the risk found. R315-101-7 requires public participation in the remedy selection. R315-101-8 requires a cleanup/management report and certificate of completion once the remedy is complete.	The selected remedies will comply through reduction of contaminants through treatment or natural attenuation that will allow the MCLs to be met. The selected remedies comply with the Principle of Non-Degradation because available information indicates concentrations are decreasing and plumes are stable or contracting. Monitoring will be conducted as part of all selected alternatives to verify that plumes are stable and concentrations are decreasing. UAC315-101-5 is substantive; however, the reference to "zoning" does not apply because U.S. Air Force installations are not subject to zoning requirements. The requirements of R315-101-1 through -8 are met through the requirements of the CERCLA process of 40 CFR 300.
Action-specific	State Regulatory Requirement	Groundwater	Corrective Action Cleanup Standards Policy; UST and CERCLA Sites – UAC R311-211	X	X	X	Applicable	Lists general criteria to be considered in establishing cleanup standards including source control, cleanup standards, and prevention of further degradation.	The source area was removed by a previous remedial action. The selected remedies will comply through treatment of the area of highest contaminant concentration in groundwater and the development of cleanup standards and RAOs based on MCLs.

TABLE 2-21
Summary of Applicable or Relevant and Appropriate Requirements for the Selected Remedies
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Type	Authority	Medium	Requirement	Applicable Remedy			Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
				PCE Plume	Shallow TCE Plume	Deep TCE Plume			
Action-specific	State Regulatory Requirement	Groundwater	Underground Injection Control Program UAC R317-7	X	X		Applicable	Sets standards and controls for the placement or injection of fluids into an aquifer or other groundwater conveyance system. The injection wells proposed will inject a biological substrate (vegetable oil) to enhance reductive dechlorination. These would be Class V injection wells (Subsurface environmental remediation wells are Class 5B6 wells); requirements for Class V injection wells include the following: • Information submitted to the UDEQ for the injection well inventory (R317-7-6.4) • Injection well will be properly operated and maintained (R317-7-5.9) • Calibration and other records will be maintained for 3 years after abandonment of injection well (R317-7-1.1 which references 40 CFR 144.51[j]) • Records of monitoring will include date, exact place and time of sampling/measurement, individual performing sampling/measurement, date analyses were performed, individual who performed analyses, analytical techniques/methods used, results (R317-7-1.1 which references 40 CFR 144.51) • Close the well so that fluids cannot move into a drinking water aquifer (R317-7-6.6).	The in situ treatment component of the selected remedies will be conducted according to established substantive requirements, criteria, and standards, as neither permitting requirements nor financial requirements apply to the cleanup.
Action-specific	State Regulatory Requirement	Groundwater	Monitoring Well Construction Standards UAC R655-4-12,13, 14, 15	X	X	X	Applicable	Established standards and requirements for drilling and abandonment of wells, including monitoring wells. These requirements include the following: • Well drilling and well construction design requirements • Well abandonment procedures • Installation by a Utah-licensed well driller and drill rig operator.	Installation of groundwater monitoring and injection wells will be completed in accordance with this requirement.

TABLE 2-21
Summary of Applicable or Relevant and Appropriate Requirements for the Selected Remedies
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Type	Authority	Medium	Requirement	Applicable Remedy: PCE Plume	Applicable Remedy: Shallow TCE Plume	Applicable Remedy: Deep TCE Plume	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Action-specific	Federal Regulatory Requirement	Oil Storage	Oil Pollution Prevention – 40 CFR 112	X	X		Applicable	Requires specific design and management requirements for oil storage to prevent spills. This ARAR is applicable if 1,320 gallons or more of any type of oil (including vegetable oils and water treatment emulsions) is stored onsite. These requirements include the following: • 100 percent secondary containment for all oil storage in containers ≥55 gallons • Provide some sort of high level alarm for containers/tanks so they cannot be overfilled • Inspect containers/tanks and appurtenances monthly • Slope oil handling areas so that they do not drain to water bodies and but do drain towards a catchment area • Train all oil handling staff annually • Secure the oil storage areas and providing adequate lighting • Prepare an Oil Spill Prevention, Control, and Countermeasures Plan and an Oil Spill Response Plan.	The selected remedy will comply with regulations by implementing these requirements if oils are stored onsite during remediation activities in quantities above 1320 gallons. The SPCC requirements would be relevant and appropriate if >1320 gallons of oils are stored onsite during remediation activities.
Action-specific	State Regulatory Requirement	Hazardous Waste	Hazardous Waste Definitions – UAC R315-1 and Identification and Listing of Hazardous Waste – UAC R315-2	X	X	X	Applicable	Provides definitions and defines how to determine whether a waste is a hazardous waste.	Wastes generated will be characterized to determine if they are hazardous wastes.
Action-specific	State Regulatory Requirement	Hazardous Waste	Hazardous Waste Generator Requirements – UAC R315-5, which adopts 40 CFR 262	X	X		Applicable	Establishes standards for generators of hazardous waste. If waste is stored in containers for longer than 90 days, then the substantive requirements of UAC R315-8 for container storage would be applicable.	The selected remedy will comply by ensuring that containerized waste (drill cuttings and other contaminated media) determined to be hazardous are properly labeled, stored, and inspected; staff is appropriately trained; and spill prevention and response procedures are in place.
Action-specific	State Regulatory Requirement	Hazardous Waste	Standards for Owners and/or Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities – UAC R315-8	X	X	X	Relevant and Appropriate	Describes the general requirements that must be implemented at hazardous waste treatment, storage, and disposal facilities, where hazardous wastes are stored for more than 90 days. Addresses closure of hazardous waste units, removal of wastes at closure, and post closure care, including putting a notice in deed if contamination is left in place	Accumulation of hazardous wastes onsite for longer than 90 days would be subject to RCRA requirements for storage facilities. Although no permit is required, storage of hazardous wastes for longer than 90 days must meet the substantive requirements for hazardous waste storage facilities. The substantive management standards include: • Contingency plan and emergency procedures • Preparedness and prevention • Training plan • Waste analysis plan • Professional Engineer certification of tanks • Inspection of tanks and containers. It is expected that hazardous waste generated would be disposed within 90 days.
Action-specific	State Regulatory Requirement	Hazardous Waste	Hazardous Waste Emergency Controls – UAC R315-9	X	X		Applicable	Outlines requirements for emergency control of hazardous waste spills, including immediate action, cleanup, and reporting.	Applicable if wastes generated during remedy implementation are characterized as hazardous waste and if those wastes are spilled.

TABLE 2-21
Summary of Applicable or Relevant and Appropriate Requirements for the Selected Remedies
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Type	Authority	Medium	Requirement	Applicable Remedy			Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
				PCE Plume	Shallow TCE Plume	Deep TCE Plume			
Action-specific	State Regulatory Requirement	Water	UPDES – UAC R317-8-7	X	X		Relevant and Appropriate	The UPDES program requires permits for the discharge of pollutants from any point source into waters of the State. Stormwater management regulatory requirements include the following: • Implementing appropriate erosion and sediment control best management practices • Controlling waste at the construction site such as concrete washout, discarded materials, chemicals, littler, sanitary waste • Implementing a SWPPP.	Although UPDES permit coverage is not required for onsite discharges of stormwater, substantive requirements, including implementing best management practices to prevent discharge of pollutants to stormwater, and SWPPP preparation are required for construction activities disturbing 1 acre or more. Construction of the selected remedy is expected to disturb less than 1 acre, so this ARAR is relevant and appropriate, not applicable. Even though a Notice of Intent submittal is not required, it will be completed to facilitate work in the end.
Action-specific	Federal Regulatory Requirement	Air Quality	Clean Air Act Regulations including Control of Emissions from New and In-Use Non-Road Compression Ignition Engines, 40 CFR 89 (most engines), 40 CFR 90 (at or below 19 kilowatts, 40 CFR 1039 (greater than 19 kilowatts) General Compliance Provisions for Highway, Stationary, and Non-road Programs 40 CFR 1068	X	X	X	Applicable	Establishes requirements for controlling emissions from non-road compression-ignition engines, including design standards, certification, and emissions testing.	The selected remedies will comply through emissions from non-road compression-ignition engines on drilling and associated equipment.
Action-specific	State Regulatory Requirement	Air Quality	Ozone Non-attainment and Maintenance Areas: General Requirements, UAC R-307-325	X	X	X	Applicable	No person shall allow or cause VOCs to be spilled, discarded, stored in open containers, or handled in any other manner that would result in greater evaporation of VOCs than would have if reasonably available control technology had been applied.	Groundwater samples will be taken to determine groundwater concentrations as the remedy is implemented. Containers containing purge water or excess samples will be kept closed and will be managed to avoid the potential for spillage to minimize the potential for VOC evaporation.
Action-specific	Federal Regulatory Requirement	Hazardous Waste	Contained-in Policy (63 Federal Register 28618–28620; May 26, 1998) Management of Soils Containing Hazardous Waste	X	X	X	Applicable	Contaminated media, of itself, is not hazardous waste. However, contaminated environmental media can be subject to regulation under RCRA if it "contains" hazardous waste (i.e., contains levels of contaminants that are above the waste criteria, or is contaminated with a listed hazardous waste [listed wastes are found in 40 CFR 261.24, see below]). Applicable since TCE and PCE are on the hazardous waste TCLP list and have been detected in soils and groundwater.	Soils and groundwater media that are removed will be tested to determine if they would be subject to this policy. Existing contamination is not believed to be from sources that include listed hazardous wastes.
Action-specific	Federal Regulatory Requirement	Hazardous Waste	Identification and Listing of Hazardous Waste – 40 CFR 261.24, as adopted by UAC R315-2-9	X	X	X	Applicable	Defines solid waste that is subject to regulation as hazardous waste including the toxicity characteristic for hazardous waste (using TCLP analyses).	The selected remedies will comply by analyzing drill cuttings and other contaminated media. If wastes are found to be hazardous, waste will be containerized, transported, and disposed of in accordance with applicable regulations.
Action-specific	State Regulatory Requirement	Hazardous Waste	General Requirements, Identification, and Listing of Hazardous Waste – UAC R315-2	X	X		Applicable	Defines those solid wastes that are subject to regulation as hazardous wastes. Includes definitions of characteristic and listed hazardous wastes. Toxicity characteristic hazardous wastes are above TCLP limits discussed in 40 CFR 261.24. Toxicity characteristic hazardous waste includes chlorinated compounds such as TCE and PCE.	The selected remedy will comply with regulations by analyzing drill cuttings and other contaminated media; if wastes are found to be hazardous, waste will be containerized, transported, and disposed in accordance with applicable regulations. Contamination is not believed to be due to listed hazardous waste.

Type	Authority	Medium	Requirement	Applicable Remedy: PCE Plume	Applicable Remedy: Shallow TCE Plume	Applicable Remedy: Deep TCE Plume	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Action-specific	State Regulatory Requirement	Air Quality	Emissions Standards. Fugitive Emissions and Fugitive Dust UAC R307-205 and R307-309	X	X	X	Applicable	Requires that steps be taken to minimize fugitive dust from all construction and demolition activities that require clearing or leveling of land greater than 0.25 acre in size or movement of construction equipment and trucks over access haul roads for any construction or demolition site. Sets limits on opacity of fugitive emissions on site and at site boundary. Requirements include the following: • Implementing measures to minimize emissions such as planting vegetative cover, watering, chemical stabilization, wind breaks • Cleaning paved roads promptly • Fugitive emissions shall not exceed 10 percent opacity at the property boundary and 20 percent anywhere onsite • Prepare a Fugitive Dust Control Plan for specific activities • Maintain records showing compliance.	The selected remedies will comply through control of fugitive dust emissions.
Action-specific	State Regulatory Requirement	Air Quality	Permit: New and Modified Sources. Air Strippers and Soil Venting Projects UAC R307-401-15 and 16	X	X	X	Applicable	Potential air emissions must be documented prior to beginning the air stripper/soil venting remediation project to show that emissions limits will not be exceeded. Emissions limits are: • < 5 tons per year of any of the following: VOCs, ozone, PM_{10}, sulfur dioxide, carbon monoxide, nitrogen oxides (R307-401-9[1][a]) • <1/10th the value of the threshold limit value - ceiling for any acute toxic air pollutant; <1/30th the value of the TLV-TWA for any chronic toxic air pollutant; and <1/90th the value of the TLV-TWA of any carcinogenic air pollutant (R307-410-5[1][d]). Sampling and calculations of emissions are required during air stripper/soil venting remedy implementation to show that emissions limits are not being exceeded. If emissions limits are exceeded, then emissions controls may be required as discussed in R307-401.	During remediation, soil gas will be monitored and compared to risk-based screening levels discussed in the ROD. If soil gas exceeds the ROD screening levels, then a soil vapor extraction system may be installed. Prior to installation of a soil vapor extraction system, potential emissions will be calculated and compared to the R307-401-16 emission limits.

TABLE 2-21
Summary of Applicable or Relevant and Appropriate Requirements for the Selected Remedies
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Type	Authority	Medium	Requirement	Applicable Remedy			Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
				PCE Plume	Shallow TCE Plume	Deep TCE Plume			

NOTES:
AFB = Air Force Base.
ARAR = Applicable or Relevant and Appropriate Requirement.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
CFR = Code of Federal Regulations.
COC = Contaminant of concern.
DCE = Dichloroethene.
EPA = U.S. Environmental Protection Agency.
IC = Institutional control.
IFC = International Fire Code.
LDR = Land disposal restriction.
MCL = Maximum Contaminant Level.
mg/L = Milligram(s) per liter.
PCE = Tetrachloroethene.
PM_{10} = Particulate matter of 10 microns in diameter or smaller.
RAO = Remedial action objective.
RCRA = Resource Conservation and Recovery Act.
ROD = Record of Decision.
SPCC = spill prevention, control, and countermeasures.
SWPPP = Stormwater pollution prevention plan.
TCE = Trichloroethene.
TCLP = Toxicity characteristic leaching procedure.
TLV-TWA = Threshold limit value - time weighted average.
UAC = Utah Administrative Code.
UDEQ = Utah Department of Environmental Quality.
UPDES = Utah Pollutant Discharge Elimination System.
UST = Underground storage tank.
VOC = Volatile organic compound.

TABLE 2-22
Cost and Effectiveness Summary for Operable Unit 10
Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Alternative	Present-Worth Cost ($ million)	Long-Term Effectiveness and Permanence	Reduction of TMV Through Treatment	Short-Term Effectiveness
PCE Plume				
Alternative 1—No Action	0	Not Evaluated. Alternative 1 is not compliant with threshold criteria.	Not Evaluated. Alternative 1 is not compliant with threshold criteria.	Not Evaluated. Alternative 1 is not compliant with threshold criteria.
Alternative 2—MNA and ICs	2.8	Moderate/Adequate	Moderate/Adequate	Good
Alternative 3—PRB, MNA, and ICs	8.9	Moderate/Adequate	Moderate/Adequate	Moderate/Adequate
Alternative 4—Groundwater Extraction and Discharge, MNA, and ICs	4.3	Moderate/Adequate	Moderate/Adequate	Moderate/Adequate
Alternative 5—Phytoremediation, MNA, and ICs	3.9	Moderate/Adequate	Moderate/Adequate	Moderate/Adequate
Alternative 6—In Situ Treatment, MNA, and ICs	1.6	Good	Good	Good
Shallow TCE Plume				
Alternative 1—No Action	0	Not Evaluated. Alternative 1 is not compliant with threshold criteria.	Not Evaluated. Alternative 1 is not compliant with threshold criteria.	Not Evaluated. Alternative 1 is not compliant with threshold criteria.
Alternative 2—MNA and ICs	3.9	Moderate/Adequate	Moderate/Adequate	Good
Alternative 3—Groundwater Extraction and Discharge, MNA, and ICs	5.5	Moderate/Adequate	Moderate/Adequate	Moderate/Adequate
Alternative 4—In Situ Treatment, MNA, and ICs	2.3	Good	Good	Good
Deep TCE Plume				
Alternative 1—No Action	0	Not Evaluated. Alternative 1 is not compliant with threshold criteria.	Not Evaluated. Alternative 1 is not compliant with threshold criteria.	Not Evaluated. Alternative 1 is not compliant with threshold criteria.
Alternative 2—MNA and ICs	2.8	Moderate/Adequate	Moderate/Adequate	Good
Alternative 3—EISB Containment, MNA, and ICs	36.2	Moderate/Adequate	Moderate/Adequate	Moderate/Adequate
Alternative 4—One-well HC, MNA, and ICs	8.7	Moderate/Adequate	Moderate/Adequate	Moderate/Adequate
Alternative 5—Three-well HC, MNA, and ICs	11.4	Moderate/Adequate	Moderate/Adequate	Moderate/Adequate

NOTES:
EISB = Enhanced in situ bioremediation.
HC = Hydraulic containment.
IC = Institutional control.
MNA = Monitored natural attenuation.
PCE = Tetrachloroethene.
PRB = Permeable reactive barrier.
TCE = Trichloroethene.
TMV = Toxicity, mobility, or volume.

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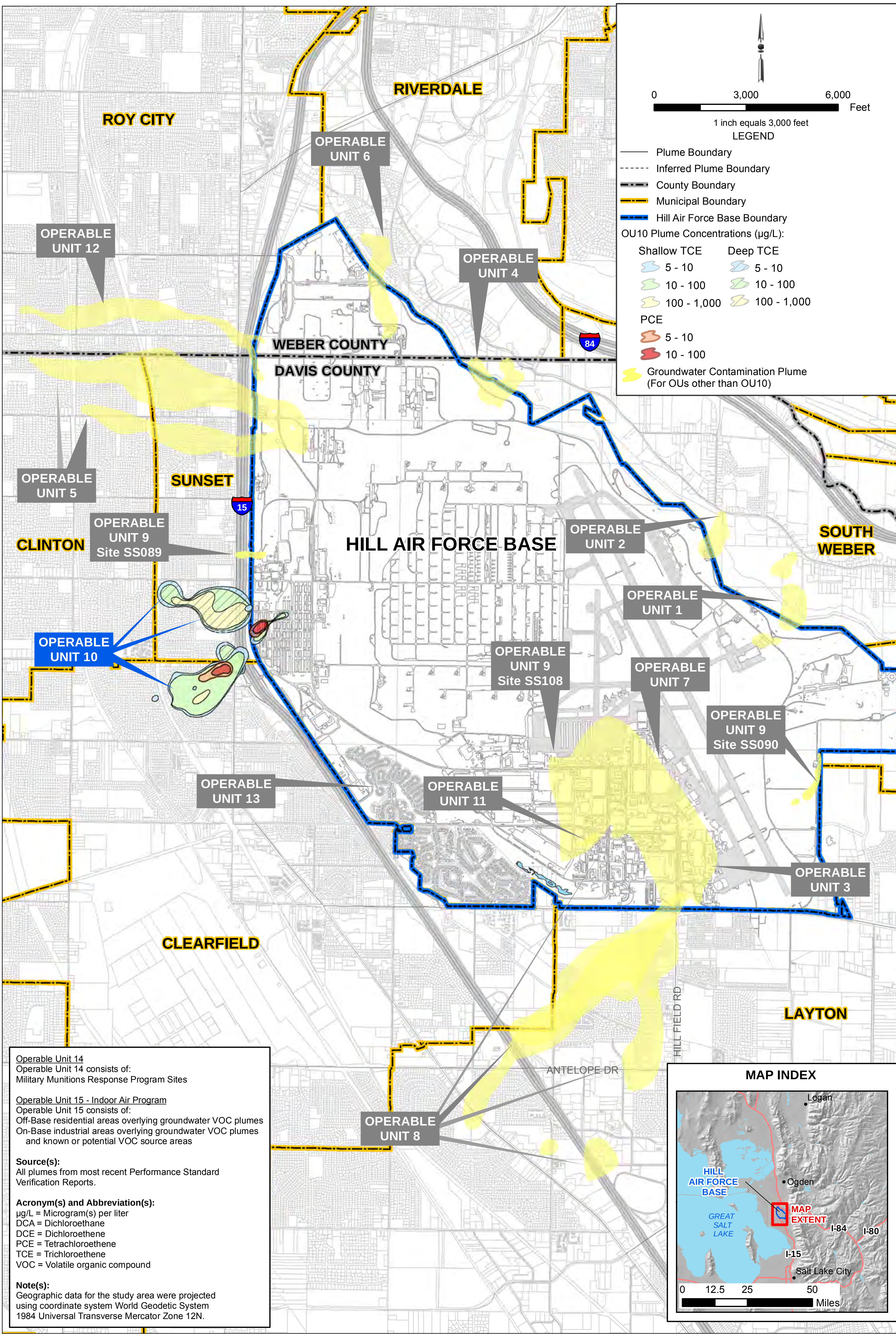

FIGURE 2-1
OPERABLE UNIT 10 SITE MAP
OPERABLE UNIT 10 RECORD OF DECISION
HILL AIR FORCE BASE, UTAH

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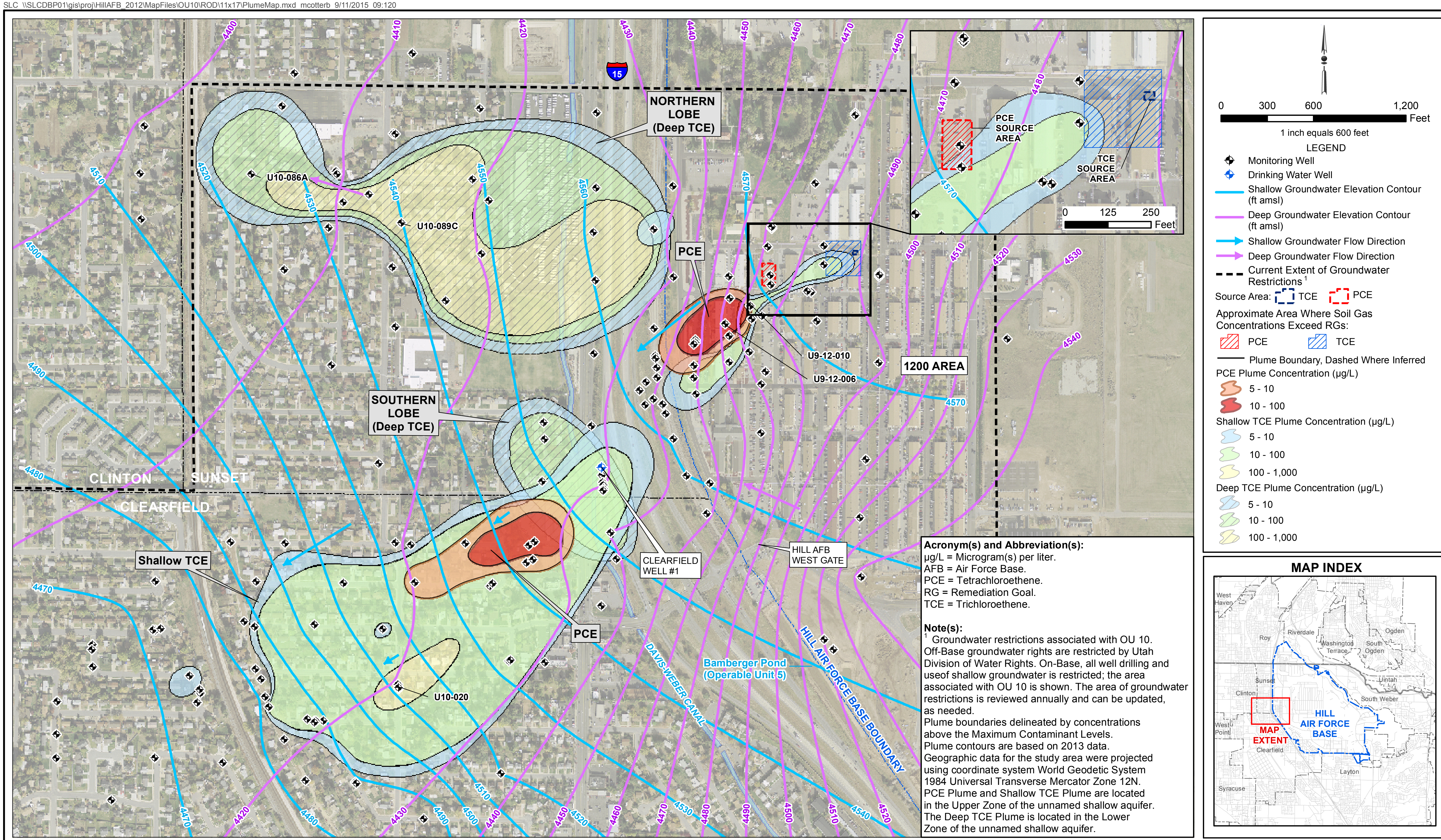

AIR FORCE CIVIL ENGINEER CENTER

FIGURE 2-2
AREAS EXCEEDING REMEDIATION GOALS FOR GROUNDWATER AND SOIL GAS
OPERABLE UNIT 10 – SITE SS109 (ZONE 1200) RECORD OF DECISION
HILL AIR FORCE BASE, UTAH

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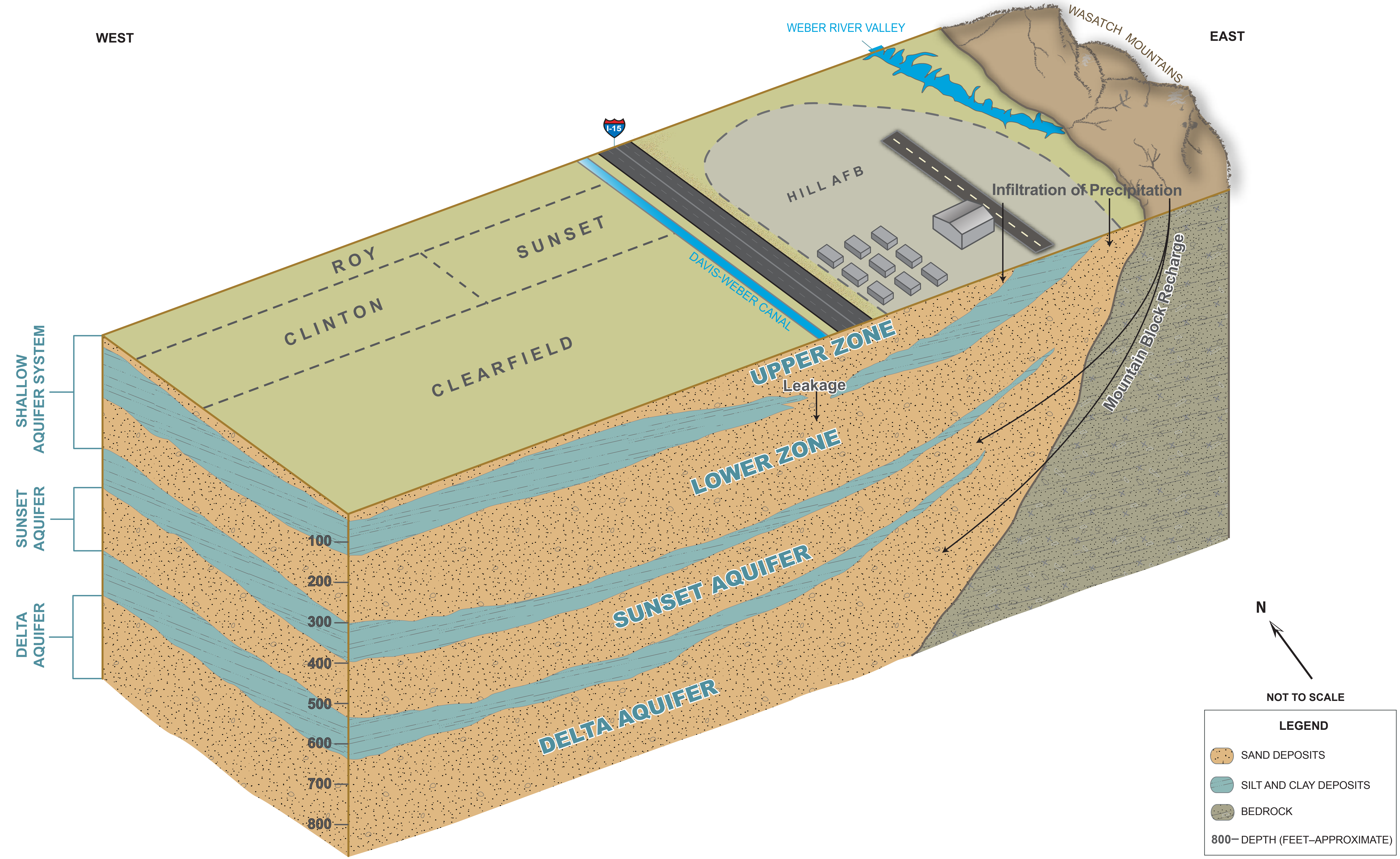

FIGURE 2-3

AQUIFER SYSTEM CONCEPTUAL MODEL FOR OPERABLE UNIT 10

OPERABLE UNIT 10 – SITE SS109 (ZONE 1200) RECORD OF DECISION

HILL AIR FORCE BASE, UTAH

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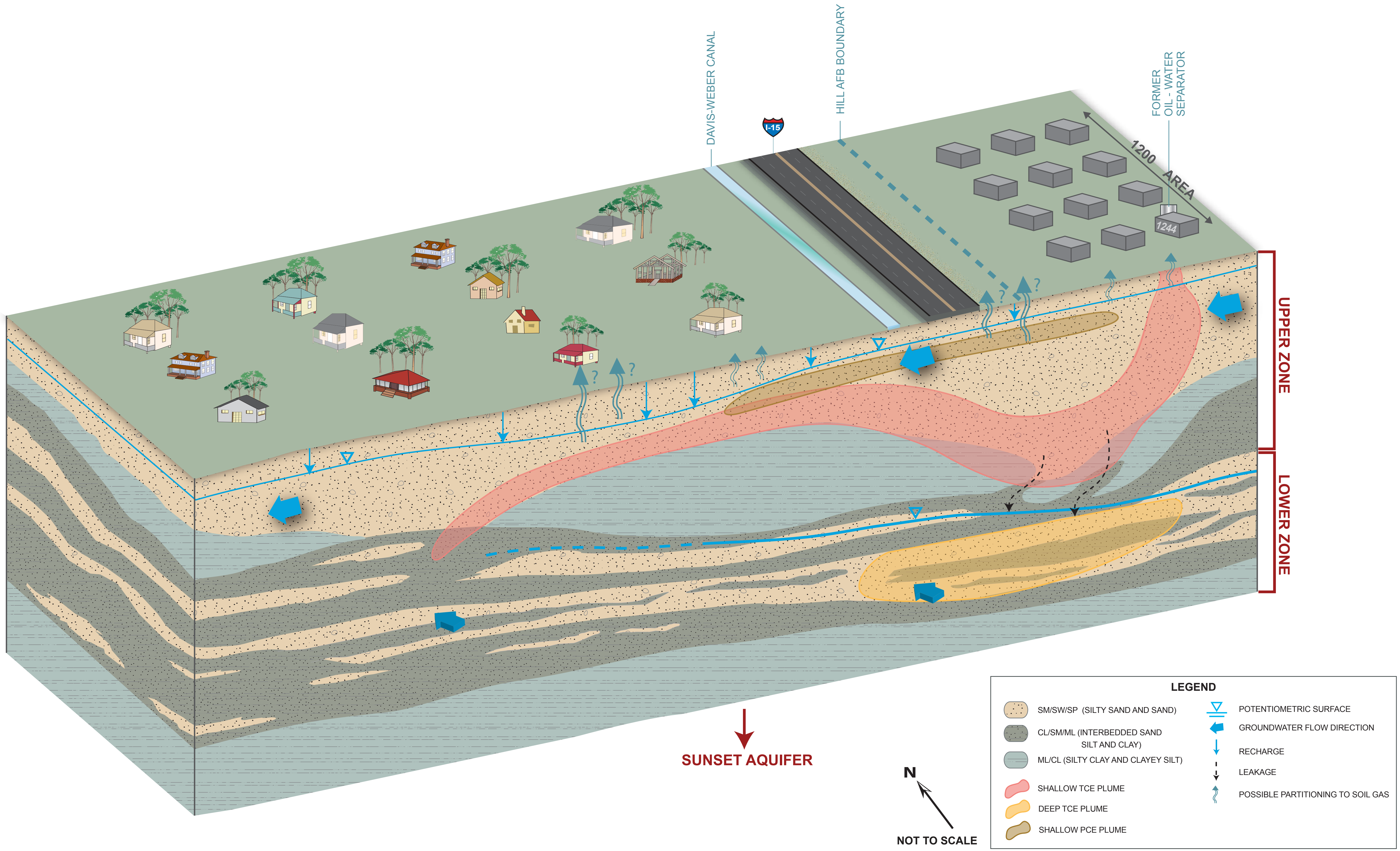

FIGURE 2-4
OPERABLE UNIT 10 CONCEPTUAL SITE MODEL
OPERABLE UNIT 10 – SITE SS109 (ZONE 1200) RECORD OF DECISION
HILL AIR FORCE BASE, UTAH

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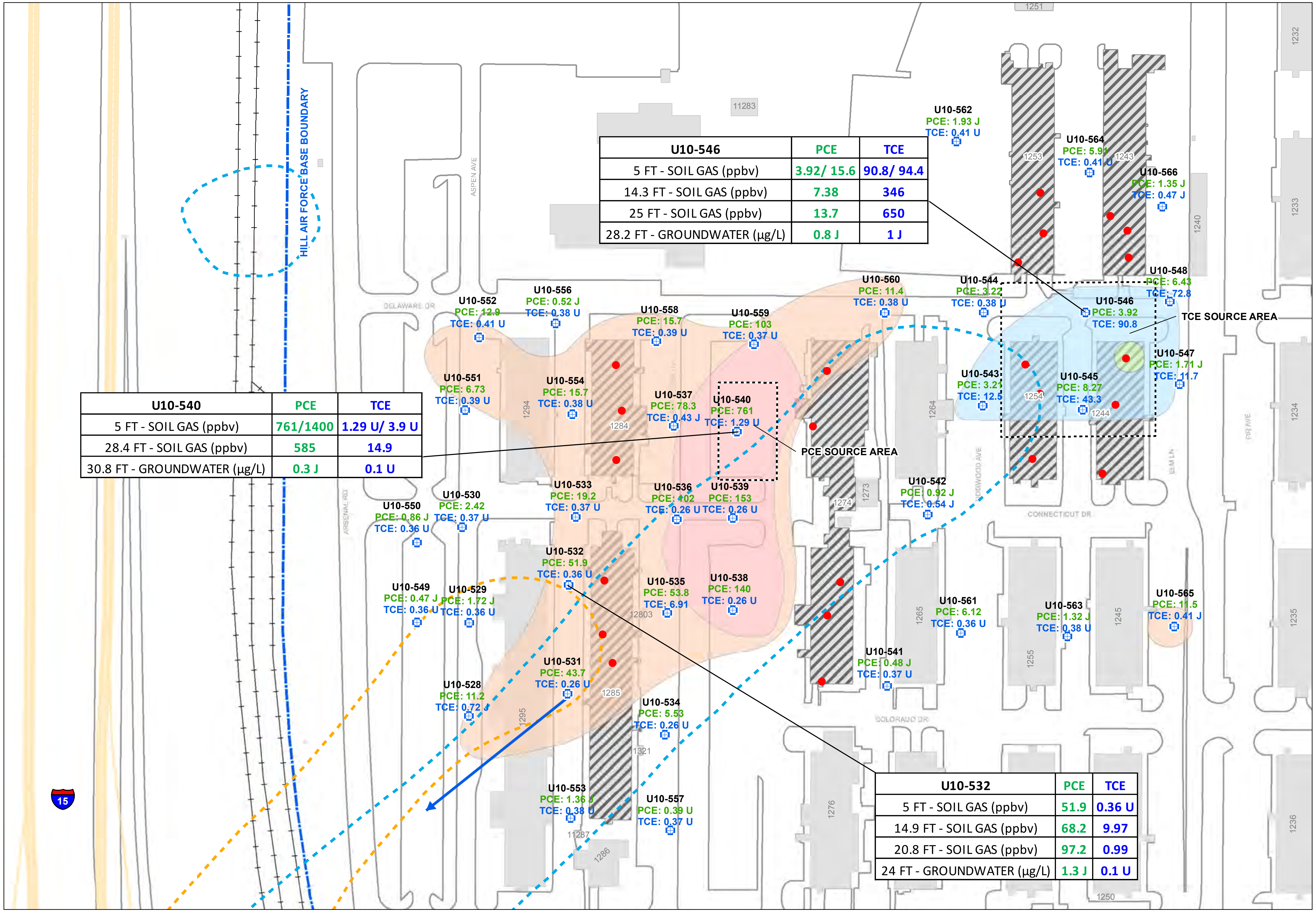

U10-546	PCE	TCE
5 FT - SOIL GAS (ppbv)	3.92/ 15.6	90.8/ 94.4
14.3 FT - SOIL GAS (ppbv)	7.38	346
25 FT - SOIL GAS (ppbv)	13.7	650
28.2 FT - GROUNDWATER (µg/L)	0.8 J	1 J

U10-540	PCE	TCE
5 FT - SOIL GAS (ppbv)	761/1400	1.29 U/ 3.9 U
28.4 FT - SOIL GAS (ppbv)	585	14.9
30.8 FT - GROUNDWATER (µg/L)	0.3 J	0.1 U

U10-532	PCE	TCE
5 FT - SOIL GAS (ppbv)	51.9	0.36 U
14.9 FT - SOIL GAS (ppbv)	68.2	9.97
20.8 FT - SOIL GAS (ppbv)	97.2	0.99
24 FT - GROUNDWATER (µg/L)	1.3 J	0.1 U

0 75 150 300 Feet

1 inch equals 150 feet

LEGEND

SOIL GAS

- Soil Gas Probe Location (5' bgs)
- PCE: X.XX PCE Concentration (ppbv)
- TCE: X.XX TCE Concentration (ppbv)
- X.XX/ X.XX Initial Sample (ppbv)/ Confirmation Sample (ppbv)
- Subslab Soil Gas Sample Location (See Figure 4-25 of OU 10 RI for Location ID's and Analytical Results)
- Approximate Area Where Soil Gas Concentrations Exceed Remedial Goals

Soil Gas PCE Concentration (ppbv)

- 10-100
- 100-1,000

Soil Gas TCE Concentration (ppbv)

- 10-100
- 100-1,000

GROUNDWATER

- PCE: X.XX PCE Concentration (µg/L)
- TCE: X.XX TCE Concentration (µg/L)
- Groundwater Flow Direction
- PCE Plume Extent
- Shallow TCE Plume Extent
- Buildings Used For Sub-Slab and Indoor-Air Sampling

Notes:
PCE and TCE groundwater plume contours based on 2011 data.
Plume boundaries delineated by concentrations above the Maximum Contaminant Levels.
Soil Gas Plumes Based on Summer 2008 Sampling Data.
Geographic data for the study area were projected using coordinate system World Geodetic System 1984 Universal Transverse Mercator Zone 12N.
µg/L = Microgram(s) per liter.
bgs = Below ground surface.
ID = Identification.
J flag = Estimated value that was detected.
OU = Operable Unit.
PCE = Tetrachloroethene.
ppbv = Part(s) per billion by volume.
RI = Remedial Investigation Report.
TCE = Trichlorethene.
U flag = Non-detect.

FIGURE 2-5

OPERABLE UNIT 10 ON-BASE SOIL GAS PROBE LOCATIONS AND RESULTS

OPERABLE UNIT 10 – SITE SS109 (ZONE 1200) RECORD OF DECISION

HILL AIR FORCE BASE, UTAH

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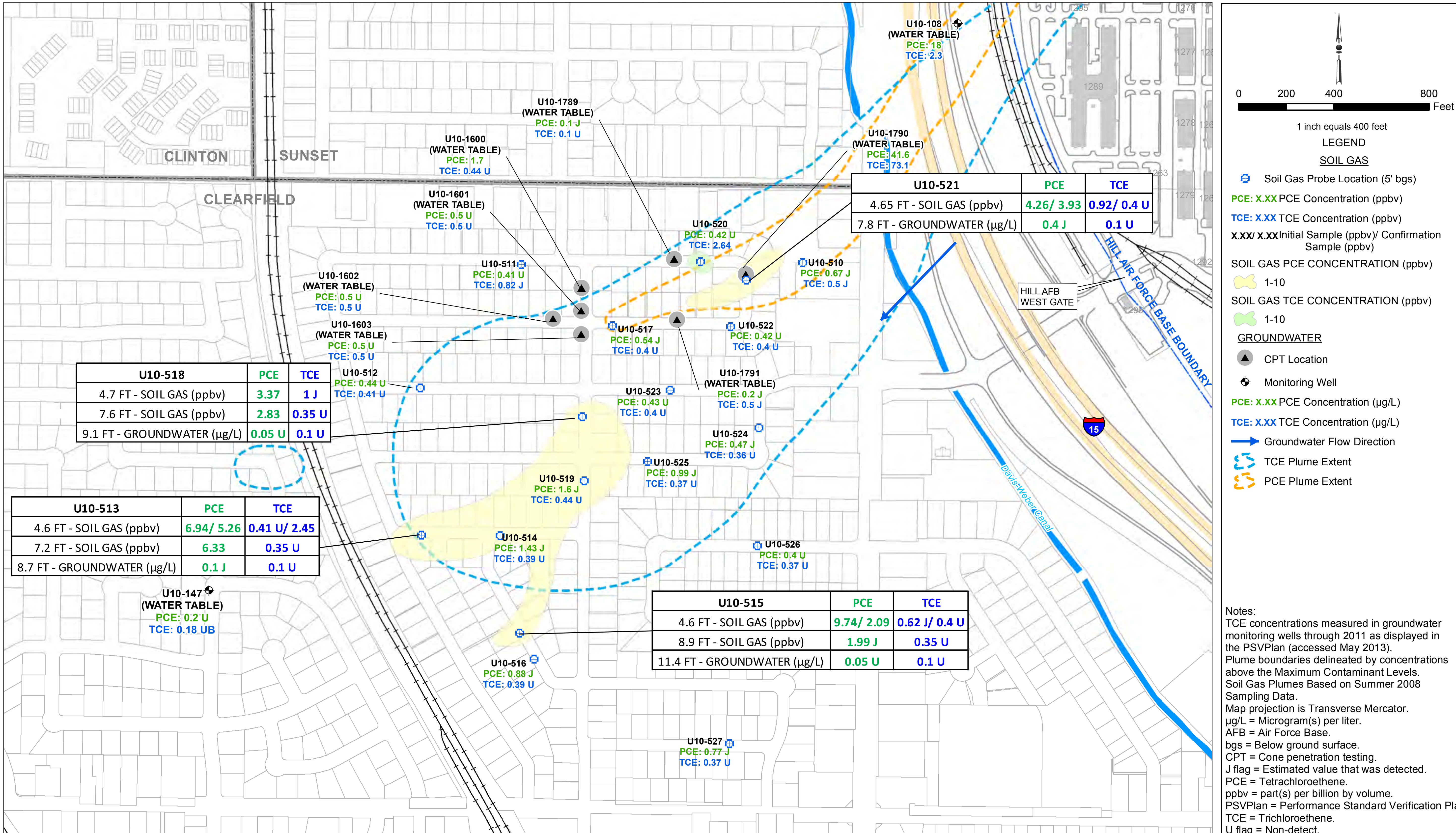

U10-521	PCE	TCE
4.65 FT - SOIL GAS (ppbv)	4.26/ 3.93	0.92/ 0.4 U
7.8 FT - GROUNDWATER (µg/L)	0.4 J	0.1 U

U10-518	PCE	TCE
4.7 FT - SOIL GAS (ppbv)	3.37	1 J
7.6 FT - SOIL GAS (ppbv)	2.83	0.35 U
9.1 FT - GROUNDWATER (µg/L)	0.05 U	0.1 U

U10-513	PCE	TCE
4.6 FT - SOIL GAS (ppbv)	6.94/ 5.26	0.41 U/ 2.45
7.2 FT - SOIL GAS (ppbv)	6.33	0.35 U
8.7 FT - GROUNDWATER (µg/L)	0.1 J	0.1 U

U10-515	PCE	TCE
4.6 FT - SOIL GAS (ppbv)	9.74/ 2.09	0.62 J/ 0.4 U
8.9 FT - SOIL GAS (ppbv)	1.99 J	0.35 U
11.4 FT - GROUNDWATER (µg/L)	0.05 U	0.1 U

Notes:
TCE concentrations measured in groundwater monitoring wells through 2011 as displayed in the PSVPlan (accessed May 2013).
Plume boundaries delineated by concentrations above the Maximum Contaminant Levels.
Soil Gas Plumes Based on Summer 2008 Sampling Data.
Map projection is Transverse Mercator.
µg/L = Microgram(s) per liter.
AFB = Air Force Base.
bgs = Below ground surface.
CPT = Cone penetration testing.
J flag = Estimated value that was detected.
PCE = Tetrachloroethene.
ppbv = part(s) per billion by volume.
PSVPlan = Performance Standard Verification Plan.
TCE = Trichloroethene.
U flag = Non-detect.

FIGURE 2-6
OPERABLE UNIT 10 OFF-BASE SOIL GAS PROBE LOCATIONS AND RESULTS
OPERABLE UNIT 10 – SITE SS109 (ZONE 1200) RECORD OF DECISION
HILL AIR FORCE BASE, UTAH

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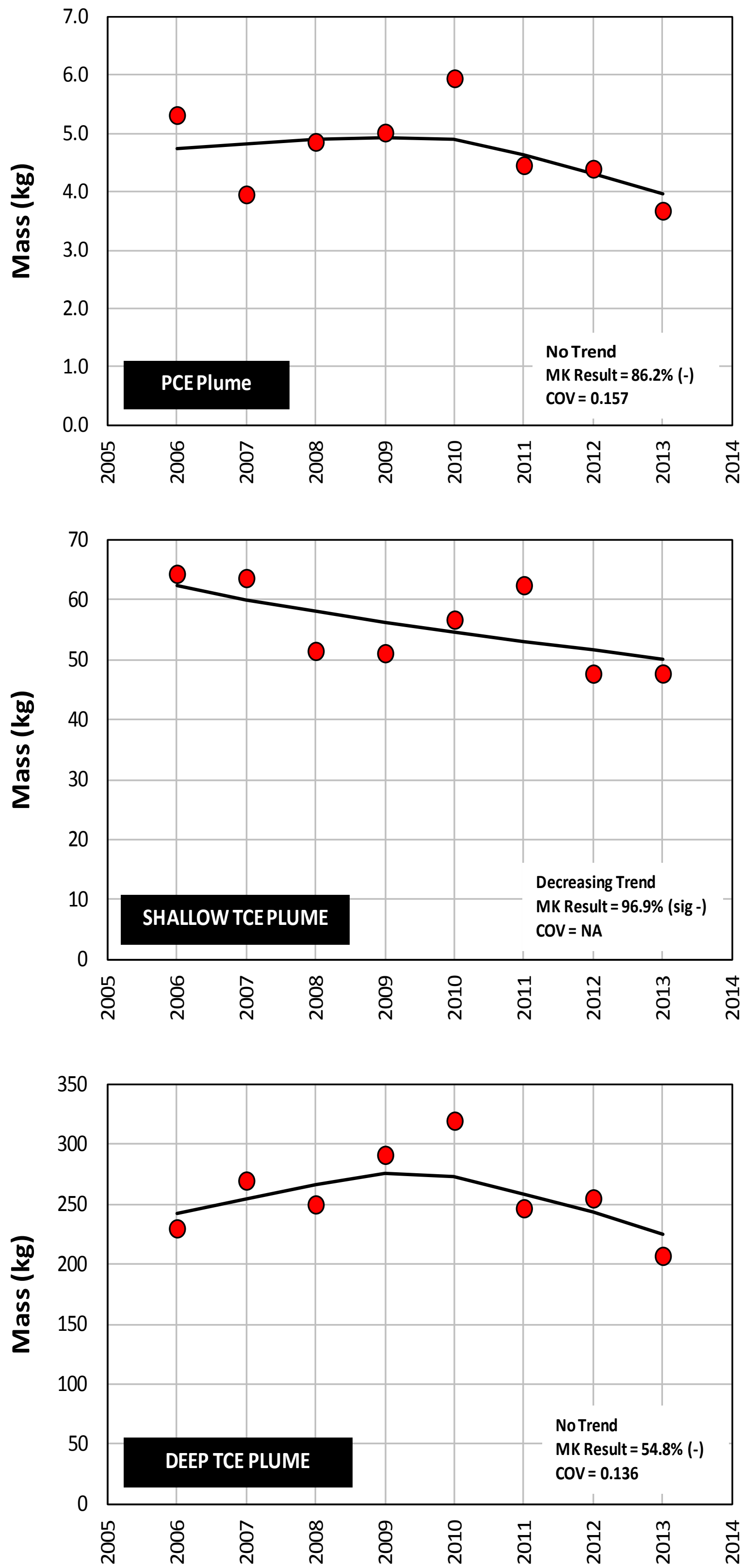

NOTES:
COV = Coefficient of variation.
kg = Kilogram(s)
MK = Mann-Kendall.
PCE = Tetrachloroethene.
TCE = Trichloroethene.

FIGURE 2-7
TIME SERIES OF DISSOLVED PCE AND TCE MASSES AT OPERABLE UNIT 10
OPERABLE UNIT 10 – SITE SS109 (ZONE 1200) RECORD OF DECISION
HILL AIR FORCE BASE, UTAH

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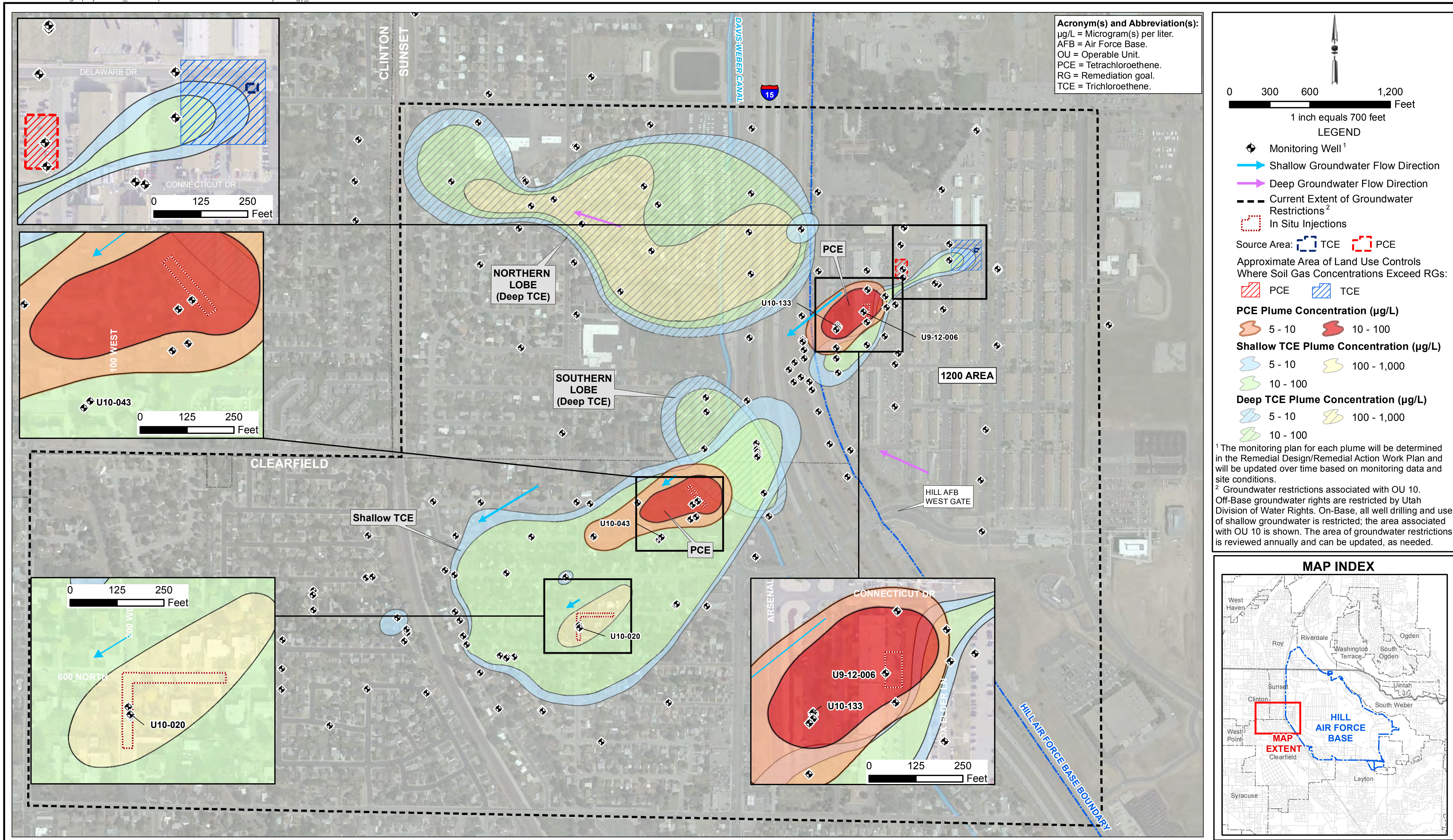

Note(s):
Plume boundaries delineated by concentrations above the Maximum Contaminant Levels.
Plume contours are based on 2013 data.
PCE Plume and Shallow TCE Plume are located in the Upper Zone of the unnamed shallow aquifer.
The Deep TCE Plume is located in the Lower Zone of the unnamed shallow aquifer.
Geographic data for the study area were projected using coordinate system World Geodetic System 1984 Universal Transverse Mercator Zone 12N.

FIGURE 2-8
REMEDIAL APPROACH FOR OPERABLE UNIT 10
OPERABLE UNIT 10 – SITE SS109 (ZONE 1200) RECORD OF DECISION
HILL AIR FORCE BASE, UTAH

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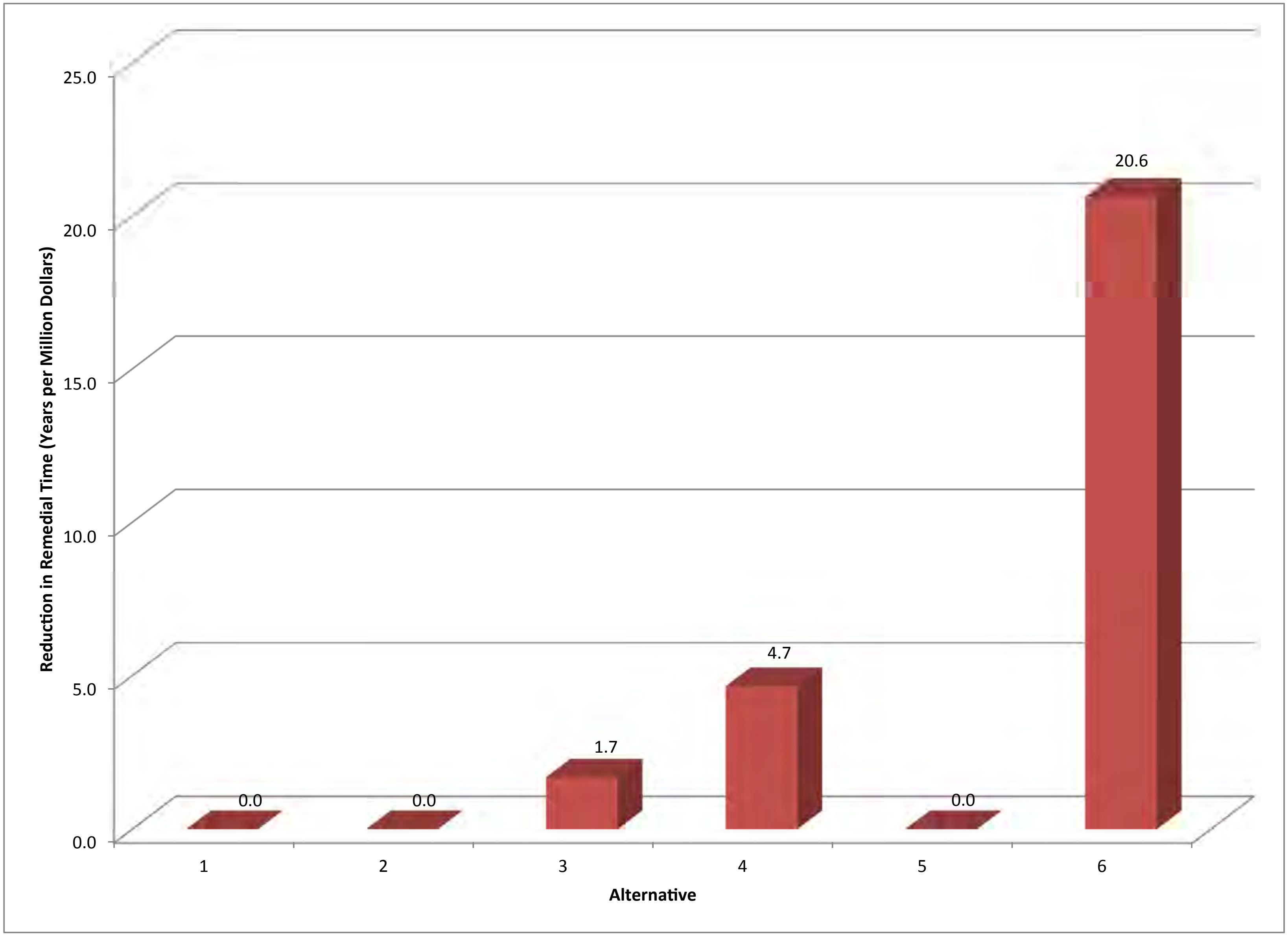

FIGURE 2-9
COST-EFFECTIVENESS SUMMARY OF REMEDIAL ALTERNATIVES FOR THE OPERABLE UNIT 10 PCE PLUME
OPERABLE UNIT 10 – SITE SS109 (ZONE 1200) RECORD OF DECISION
HILL AIR FORCE BASE, UTAH

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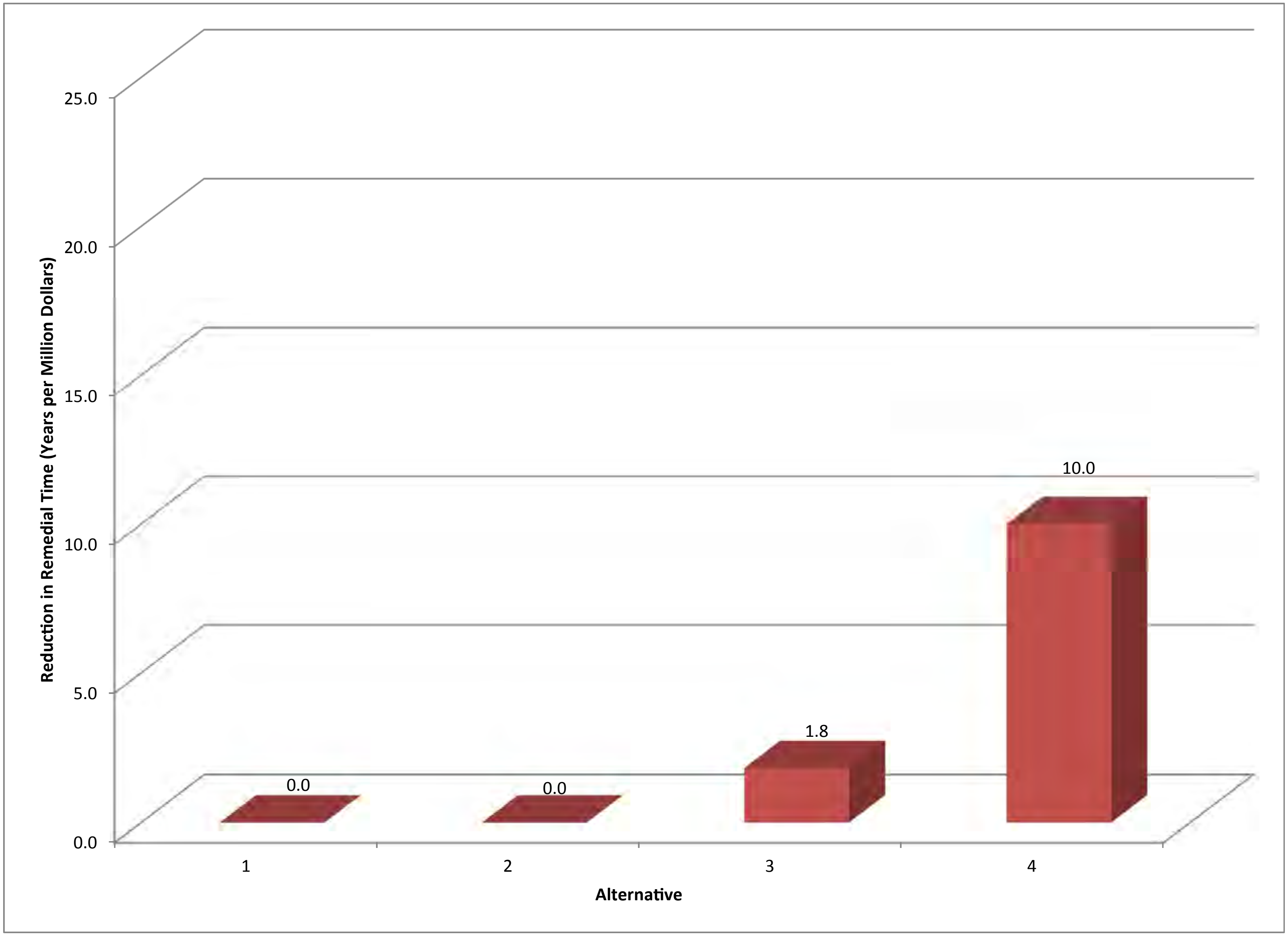

FIGURE 2-10
COST-EFFECTIVENESS SUMMARY OF REMEDIAL ALTERNATIVES FOR THE OPERABLE UNIT 10 SHALLOW TCE PLUME
OPERABLE UNIT 10 – SITE SS109 (ZONE 1200) RECORD OF DECISION
HILL AIR FORCE BASE, UTAH

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3.0 Responsiveness Summary

This section provides a summary of the public comments regarding the Proposed Plan (EA 2015a) for remedial action at OU 10 – Site SS109 (Zone 1200), Hill AFB, Utah. A notice of availability of the Proposed Plan and opportunity for public comment (Appendix C) was published in the Ogden Standard Examiner on 13 February 2015. At the time of the public review period, the USAF had selected the following Preferred Alternatives for OU 10:

- PCE Alternative 6—In Situ Treatment, MNA, and ICs
- Shallow TCE Alternative 4—In Situ Treatment, MNA, and ICs
- Deep TCE Alternative 2—MNA and ICs.

An open house public meeting for OU 10 was held from 5:00 to 7:00 p.m. on Thursday, 5 March 2015 at Clearfield City Hall. Representatives from Hill AFB, EPA, and UDEQ were available to explain and answer questions about the proposed remedies for OU 10. A sign-in sheet with the names of those in attendance at the public meeting is included in Appendix C.

No comments were received during the public meeting, nor were any comments received during the public comment period.

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Appendix A
Plume Stability Evaluation

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A.0 Plume Stability Evaluation

A.1 Introduction

Stability of the deep trichloroethene (TCE), shallow TCE, and shallow tetrachloroethene (PCE) groundwater plumes at Operable Unit (OU) 10 were assessed based on trends of contaminant concentrations in monitoring locations and changes of dissolved contaminant mass over time. Statistical trend analysis was combined with spatial integration of the groundwater concentration data to provide an assessment of changes in point concentrations at individual monitoring locations, as well as the change in the total integrated mass within each plume.

A.2 Methodology

Statistical inference concerning concentration trends of PCE and TCE data collected from the monitoring locations at OU 10 was made using the non-parametric Mann-Kendall test (Gilbert 1987). The Mann-Kendall test is based on the idea that a lack of trend should correspond to a time series plot that fluctuates randomly about a constant mean level, with no visually apparent upward or downward pattern (U.S. Environmental Protection Agency [EPA] 2009). As a non-parametric procedure, the Mann-Kendall test does not require the underlying data to follow a specific distribution. The test compares the relative magnitudes of the sample data rather than the data values. Analytical data reported at less than the reporting or detection limit (non-detects) can be used by assigning them a common value that is smaller than the smallest measured value in the data set (Gilbert 1987). For this analysis, a value of 0.05 micrograms per liter (µg/L) was assigned to non-detects.

For monitoring wells where no trend could be statistically determined at the 95 percent confidence level, concentrations were deemed stable if the coefficient of variation (COV) was less than one. The COV is a statistical measure of how the individual data points vary about the mean value and is defined as the standard deviation divided by the sample mean (EPA 2009). The COV is a relative measure of variation in the groundwater concentration data, and can be affected by the magnitude of the concentrations. As such, concentrations that are high can include significant variation while exhibiting a small COV. While there is no objective basis for using a particular value of COV to determine stability, values greater than 1 indicate that the data exhibit a greater amount of scatter about the mean.

Spatial statistical analyses of the PCE and TCE concentration data were performed using a weighted “area-of-influence” approach. This approach was implemented using Thiessen polygons to evaluate the temporal change in the mass of PCE and TCE in groundwater at the site. The Thiessen polygon method (EPA 1998) is a spatially integrated approach that provides an approximation of the dissolved mass present in groundwater. The approach assumes that the estimated mass can be calculated by multiple polygons of defined area, depth, and concentration.

The comparison of mass is a relational process, where the individual mass for a given year is considered to be an approximation but is comparable over time when a consistent monitoring well network is used. Due to changes in the monitoring well network, proxy values (i.e., prior sampling event results) were assigned to those wells with missing concentration data for a given year to maintain consistency and comparison on a year-to-year basis. After the mass was estimated for each year, the Mann-Kendall test was applied to the set of calculated mass estimates for each plume (shallow and deep TCE and PCE) to evaluate whether the total dissolved mass exhibited a statistical trend. Due to an incomplete temporal record for the Thiessen well networks, mass calculations were not conducted prior to 2006.

The temporal behavior of both the concentration data and the dissolved mass for each plume was examined graphically to confirm the results of the trend analysis. A time series plot of concentrations and dissolved mass was generated for each monitoring well and plume, respectively, and included the use of a locally weighted scatter plot smoothing curve to visually show the overall trend in the data (Cleveland 1979).

A.3 Results

A.3.1 Shallow TCE Plume

Table A-1 presents the trends in TCE concentrations for monitoring locations associated with the shallow TCE groundwater plume. Of the 103 shallow monitoring locations, the trend analysis indicates the following:

- Decreasing trends or greater than 50 percent non-detects at 74 locations
- Insufficient data were available to test for a trend at four locations
- No statistical trend could be determined at 18 locations, 15 of which exhibit stable concentrations based on the COV
- Increasing trends at seven locations.

The results of the trend analysis, including time series for those wells showing increasing trends, are shown graphically on Figure A-1 in relationship to the TCE isoconcentration contour lines. The contour lines represent the inferred extent of TCE contamination in shallow groundwater during spring 2012 as presented in the *Operable Unit 10 Performance Standard Verification Plan* (PSVPlan) (Hill AFB 2014).

Monitoring locations exhibiting increasing trends include U10-039 (49 µg/L in first quarter 2013), U10-060 (7.9 µg/L in first quarter 2013), U10-088A (5.7 µg/L in first quarter 2013), U10-099 (1.5 µg/L in first quarter 2013), U10-133 (0.46 µg/L in first quarter 2013), U10-143 (13 µg/L in first quarter 2013), and U9-12-006 (16 µg/L in first quarter 2013). Concentrations at U9-12-006 and U10-133 exhibit a high degree of variability, which may explain the Mann-Kendall test result, more so than a monotonic increase in concentrations over time. Recently, concentrations of TCE appear to be decreasing at U10-039 and U10-099; however, additional data are needed to confirm this short-term behavior.

Figure A-2 shows the estimated mass of dissolved TCE in the shallow plume since 2006. The dissolved mass was estimated assuming a uniform Thiessen polygon thickness of 25 feet and 40 percent porosity. The results indicate an approximate 20 percent decrease in total dissolved mass within the shallow plume since 2006.

A.3.2 Deep TCE Plume

Table A-2 presents the trends in TCE concentrations for monitoring locations associated with the deep TCE groundwater plume. Of the 145 deep monitoring locations, the trend analysis indicates the following:

- Decreasing trends or greater than 50 percent non-detects at 129 locations
- Insufficient data were available to test for a trend at one location

- No statistical trend could be determined at 11 locations, 10 of which exhibit stable concentrations based on the COV

- Increasing trends at four locations.

The results of the trend analysis, including time series for those wells showing increasing trends, are shown graphically on Figure A-3 in relationship to the TCE isoconcentration contour lines. The contour lines represent the inferred extent of TCE contamination in deep groundwater during spring 2012 as presented in the PSVPlan (Hill AFB 2014).

Monitoring locations exhibiting increasing trends include U10-049, U10-050C, U10-086A, and U10-151B as presented on Figure A-3. With the exception of the above monitoring wells, concentrations of TCE in the lower zone appear to be decreasing.

Figure A-4 shows the estimated mass of dissolved TCE in the deep plume since 2006. The dissolved mass was estimated assuming a uniform Thiessen polygon thickness of 50 feet and 40 percent porosity. Although statistically no trend could be determined at the 95 percent confidence level, the total dissolved mass appears stable based on the COV. Since about 2010, the mass appears to be decreasing but additional data are required to determine whether this decrease is statistically significant.

A.3.3 Shallow PCE Plume

Table A-3 presents the trends in PCE concentrations for monitoring locations associated with the shallow PCE groundwater plume. Of the 37 shallow monitoring locations, the trend analysis indicates the following:

- Decreasing trends or greater than 50 percent non-detects at 24 locations

- No statistical trend could be determined at eight locations, six of which, exhibit stable concentrations based on the COV

- Increasing trends at five locations.

The results of the trend analysis, including time series for those wells showing increasing trends, are shown graphically on Figure A-5 in relationship to the PCE isoconcentration contour lines. The contour lines represent the inferred extent of PCE contamination in shallow groundwater during spring 2012 as presented in the PSVPlan (Hill AFB 2014).

Monitoring locations exhibiting increasing trends include U10-037 (8.0 µg/L in first quarter 2013), U10-043 (1.6 µg/L in first quarter 2013), U10-088A (0.72 µg/L in first quarter 2013), U10-143 (2.0 µg/L in first quarter 2013), and U10-175 (29 µg/L in first quarter 2013). With the exception of U10-175, the concentrations of PCE reported at these locations have been consistently less than 10 µg/L. At U10-175, the maximum concentration of PCE was 82 µg/L, which was reported in November 2010. The concentration of PCE has decreased since that time and in January 2013, the concentration was 29 µg/L.

Figure A-6 shows the estimated mass of dissolved PCE in the shallow plume since 2006. The dissolved mass was estimated assuming a uniform Thiessen polygon thickness of 20 feet and 40 percent porosity. Although statistically no trend could be determined at the 95 percent confidence level, the total dissolved mass appears stable based on the COV. Since about 2010, the mass appears to be decreasing but additional data are required to determine whether this decrease is statistically significant.

A.4 Conclusions

A.4.1 Shallow TCE Plume

The majority of monitoring locations for the shallow TCE plume show decreasing trends or in the case where no trend can statistically be determined, concentrations appear stable based on the COV. Concentrations of TCE at monitoring locations outside the plume boundary have consistently been below 5 µg/L. The dissolved mass of TCE in the shallow plume is decreasing. Data suggest that the shallow TCE plume is stable or likely receding.

A.4.2 Deep TCE Plume

The majority of monitoring locations for the deep TCE plume show decreasing trends or in the case where no trend can statistically be determined, concentrations appear stable based on the COV. Concentrations of TCE at monitoring locations outside the plume boundary have consistently been below 5 µg/L. The dissolved mass of TCE in the deep plume appears stable. Overall, the core of the deep TCE plume appears to be contracting. Localized expansion may be occurring near U10-086A, but with decreasing upgradient concentrations, any expansion is expected to be transient.

A.4.3 Shallow PCE Plume

The majority of monitoring locations for the shallow PCE plume show decreasing trends or in the case where no trend can statistically be determined, concentrations appear stable based on the COV. However, concentrations of PCE near the leading edge of the plume appear to be increasing. Although concentrations in these wells are relatively low and the plume mass appears stable, these increasing trends in downgradient monitoring locations preclude a determination that the PCE plume is stable.

A.5 References

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TABLE A-1

Trend Analysis for Shallow TCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decision

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U10-011	25	0	25	100	2.20	30.0	15.6	16.0	57.4% (-)	**No Trend**	**Stable**	17.0	Jan-13
U10-012	21	0	21	100	1.70	30.1	14.8	15.0	100.0% (sig -)	**Decreasing**	NA	1.70	Mar-13
U10-013	2	19	21	10	0.050	0.230	0.060	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-014	1	20	21	5	0.050	0.250	0.060	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-019	23	1	24	96	0.050	129	45.9	42.0	100.0% (sig -)	**Decreasing**	NA	19.0	Feb-13
U10-020	24	0	24	100	110	489	188	162	91.4% (-)	**No Trend**	**Stable**	110	Feb-13
U10-021	7	13	20	35	0.050	3.00	0.332	0.050	NA	>50% ND	NA	3.00	Feb-13
U10-025	2	15	17	12	0.050	3.10	0.245	0.050	NA	>50% ND	NA	3.10	Feb-13
U10-026	14	5	19	74	0.050	0.500	0.238	0.230	99.6% (sig -)	**Decreasing**	NA	0.230	Feb-13
U10-027	19	0	19	100	1.50	3.20	2.27	2.20	98.6% (sig -)	**Decreasing**	NA	2.20	Feb-13
U10-028	23	0	23	100	0.610	13.1	3.37	1.80	100.0% (sig -)	**Decreasing**	NA	0.620	Feb-13
U10-029	19	0	19	100	15.0	60.1	36.0	32.2	99.0% (sig -)	**Decreasing**	NA	15.0	Feb-13
U10-030	6	12	18	33	0.050	0.320	0.109	0.050	NA	>50% ND	NA	0.320	Feb-13
U10-031	15	4	19	79	0.050	10.8	1.51	0.400	100.0% (sig -)	**Decreasing**	NA	0.290	Feb-13
U10-032	13	6	19	68	0.050	1.10	0.426	0.260	93.4% (-)	**No Trend**	**Stable**	0.250	Feb-13
U10-033	2	17	19	11	0.050	0.260	0.069	0.050	NA	>50% ND	NA	0.260	Feb-13
U10-034	4	15	19	21	0.050	0.980	0.124	0.050	NA	>50% ND	NA	0.980	Mar-13
U10-035	24	0	24	100	30.0	160	88.1	78.5	100.0% (sig -)	**Decreasing**	NA	30.0	Feb-13
U10-036	23	0	23	100	8.10	21.3	13.3	12.9	99.2% (sig -)	**Decreasing**	NA	8.10	Feb-13
U10-037	22	0	22	100	22.0	55.0	40.6	44.9	54.5% (+)	**No Trend**	**Stable**	28.0	Jan-13
U10-038	1	17	18	6	0.050	0.300	0.064	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-039	17	1	18	94	0.050	80.0	47.0	49.9	100.0% (sig +)	**Increasing**	NA	49.0	Mar-13
U10-040	2	16	18	11	0.050	0.240	0.068	0.050	NA	>50% ND	NA	0.190	Jan-13
U10-041	2	15	17	12	0.050	0.580	0.096	0.050	NA	>50% ND	NA	0.580	Feb-13
U10-043	23	0	23	100	66.0	262	172	169	100.0% (sig -)	**Decreasing**	NA	66.0	Jan-13
U10-044	2	15	17	12	0.050	0.510	0.089	0.050	NA	>50% ND	NA	0.510	Feb-13
U10-045	8	9	17	47	0.050	1.00	0.397	0.050	NA	>50% ND	NA	0.820	Feb-13
U10-046	1	17	18	6	0.050	0.290	0.063	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-052	1	10	11	9	0.050	0.290	0.072	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-053	9	0	9	100	3.00	5.00	4.10	4.20	69.4% (+)	**No Trend**	**Stable**	3.00	Feb-13
U10-060	15	4	19	79	0.050	8.00	3.06	2.00	100.0% (sig +)	**Increasing**	NA	7.90	Feb-13
U10-061	1	16	17	6	0.050	0.200	0.059	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-062	14	0	14	100	21.0	73.0	52.0	58.4	96.0% (sig -)	**Decreasing**	NA	35.0	Jan-13
U10-063	1	0	1	100	0.200	0.200	NA	NA	NA	IS	NA	0.200	Feb-09

TABLE A-1

Trend Analysis for Shallow TCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decision

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U10-064	16	0	16	100	0.440	2.50	1.45	1.40	100.0% (sig -)	Decreasing	NA	1.10	Feb-13
U10-065	7	9	16	44	0.050	33.7	2.45	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-068A	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-068B	1	14	15	7	0.050	0.200	0.060	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-069A	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-069B	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-070A	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-070B	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-071A	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-071B	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-072A	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-072B	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-072C	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-073	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-074	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-075A	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-075B	1	10	11	9	0.050	0.470	0.088	0.050	NA	>50% ND	NA	0.470	Feb-13
U10-076A	15	0	15	100	2.00	22.0	10.4	9.80	57.7% (-)	No Trend	Stable	16.0	Feb-13
U10-076B	1	14	15	7	0.050	0.190	0.059	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-077A	1	10	11	9	0.050	10.0	0.955	0.050	NA	>50% ND	NA	10.0	Feb-13
U10-077B	1	10	11	9	0.050	0.760	0.115	0.050	NA	>50% ND	NA	0.760	Feb-13
U10-078A	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-078B	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-088A	11	0	11	100	2.60	5.70	3.68	3.80	99.2% (sig +)	Increasing	NA	5.70	Jan-13
U10-088B	2	8	10	20	0.050	0.210	0.079	0.050	NA	>50% ND	NA	0.180	Jan-13
U10-099	16	0	16	100	0.800	2.20	1.42	1.45	98.9% (sig +)	Increasing	NA	1.50	Mar-13
U10-100	9	0	9	100	0.530	1.50	0.954	0.800	99.5% (sig -)	Decreasing	NA	0.530	Mar-13
U10-101	2	5	7	29	0.050	0.260	0.110	0.050	NA	>50% ND	NA	0.260	Mar-13
U10-106	11	0	11	100	3.90	6.30	4.98	4.80	87.5% (-)	No Trend	Stable	4.40	Jan-13
U10-122	5	7	12	42	0.050	0.400	0.146	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-132	11	0	11	100	2.10	7.70	4.30	3.90	85.9% (+)	No Trend	Stable	3.00	Feb-13
U10-133	8	8	16	50	0.050	2.50	0.645	0.105	96.8% (sig +)	Increasing	NA	0.460	Jan-13
U10-134	11	0	11	100	2.70	5.20	4.13	4.00	50.0% (-)	No Trend	Stable	2.70	Jan-13
U10-135	6	5	11	55	0.050	0.300	0.143	0.180	84.0% (+)	No Trend	Stable	0.180	Jan-13

TABLE A-1

Trend Analysis for Shallow TCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decision

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U10-136	0	8	8	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-139A	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-139B	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-139C	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-140A	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-140B	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-140C	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-141A	1	7	8	13	0.050	0.200	0.069	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-141B	0	8	8	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-142	12	0	12	100	28.0	52.0	40.1	42.0	55.3% (-)	**No Trend**	**Stable**	29.0	Jan-13
U10-143	8	0	8	100	6.90	13.0	10.1	10.3	95.8% (sig +)	**Increasing**	NA	13.0	Feb-13
U10-144	1	7	8	13	0.050	1.50	0.231	0.050	NA	>50% ND	NA	1.50	Feb-13
U10-157	21	0	21	100	24.5	131	54.5	49.0	56.0% (+)	**No Trend**	**Stable**	33.0	Jan-13
U10-167	16	3	19	84	0.050	160	46.5	39.0	93.4% (+)	**No Trend**	**Not Stable**	43.0	Mar-13
U10-172	14	3	17	82	0.050	72.0	12.3	5.30	100.0% (sig -)	**Decreasing**	NA	2.10	Jan-13
U10-175	22	0	22	100	33.0	72.0	54.9	54.9	86.4% (-)	**No Trend**	**Stable**	33.0	Jan-13
U9-12-001	2	24	26	8	0.050	0.310	0.068	0.050	NA	>50% ND	NA	0.250	Mar-13
U9-12-002	27	0	27	100	9.50	34.6	20.8	20.6	100.0% (sig -)	**Decreasing**	NA	9.60	Mar-13
U9-12-003	0	4	4	0	0.050	0.050	0.050	0.050	NA	IS	NA	0.050	Sep-01
U9-12-004	20	0	20	100	2.60	45.0	14.0	9.25	100.0% (sig -)	**Decreasing**	NA	2.60	Mar-13
U9-12-005	24	2	26	92	0.050	6.00	2.37	1.70	99.4% (sig -)	**Decreasing**	NA	0.780	Feb-13
U9-12-006	21	2	23	91	0.050	36.5	9.06	9.00	96.8% (sig +)	**Increasing**	NA	16.0	Mar-13
U9-12-007	26	0	26	100	1.60	38.2	9.36	5.30	100.0% (sig -)	**Decreasing**	NA	2.90	Feb-13
U9-12-008	3	22	25	12	0.050	0.800	0.086	0.050	NA	>50% ND	NA	0.190	Mar-13
U9-12-009	7	18	25	28	0.050	0.800	0.176	0.050	NA	>50% ND	NA	0.170	Mar-13
U9-12-010	30	0	30	100	19.0	184	77.5	60.9	100.0% (sig -)	**Decreasing**	NA	19.0	Feb-13
U9-12-011	26	0	26	100	3.40	22.0	10.4	9.30	100.0% (sig -)	**Decreasing**	NA	3.80	Feb-13
U9-12-012	3	20	23	13	0.050	1.40	0.161	0.050	NA	>50% ND	NA	1.10	Feb-13
U9-12-013	24	0	24	100	0.600	6.60	2.81	2.80	93.5% (-)	**No Trend**	**Stable**	2.00	Feb-13
U9-12-014	2	0	2	100	0.400	0.500	0.450	0.450	NA	IS	NA	0.500	Oct-01
U9-12-015	17	0	17	100	13.0	78.7	35.6	31.0	73.2% (-)	**No Trend**	**Stable**	13.0	Feb-13
U9-12-016	18	0	18	100	1.00	6.10	2.90	2.55	99.0% (sig -)	**Decreasing**	NA	1.00	Feb-13
U9-12-017	24	0	24	100	0.500	21.4	2.38	1.35	50.0% (.)	**No Trend**	**Not Stable**	3.00	Feb-13

TABLE A-1

Trend Analysis for Shallow TCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decisior

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U9-12-018	13	11	24	54	0.050	1.10	0.193	0.200	52.0% (-)	**No Trend**	**Not Stable**	1.10	Feb-13
U9-12-019	1	0	1	100	13.0	13.0	NA	NA	NA	IS	NA	13.0	Aug-00

NOTES:

µg/L = Microgram(s) per liter.

>50% ND = greater than 50 percent nondetects.

IS = Insufficient data (less than six sample results).

Max = Maximum.

Min = Minimum.

MK = Mann Kendall.

NA = Not applicable.

Trend analysis performed using MK single-tailed test at 0.05 significance level.

For monitoring points exhibiting no trend at the 95 percent confidence level, concentrations are deemed stable if the coefficient of variation is equal to or less than 1.

TABLE A-2

Trend Analysis for Deep TCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decision

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U10-022	4	17	21	19	0.050	16.9	0.902	0.050	NA	>50% ND	NA	0.270	Feb-13
U10-023	0	21	21	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-024	1	19	20	5	0.050	0.420	0.069	0.050	NA	>50% ND	NA	0.420	Feb-13
U10-042	21	2	23	91	0.050	29.5	18.4	21.0	84.8% (+)	**No Trend**	**Stable**	19.0	Mar-13
U10-047	2	16	18	11	0.050	0.190	0.064	0.050	NA	>50% ND	NA	0.160	Mar-13
U10-048	0	17	17	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-049	19	1	20	95	0.050	260	134	156	100.0% (sig +)	**Increasing**	NA	150	Jan-13
U10-050A	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-050B	0	22	22	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-050C	22	0	22	100	0.700	27.0	16.1	18.5	100.0% (sig +)	**Increasing**	NA	20.0	Feb-13
U10-051	20	0	20	100	73.0	153	117	119	99.9% (sig -)	**Decreasing**	NA	75.0	Feb-13
U10-054A	1	18	19	5	0.050	0.200	0.058	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-054B	0	17	17	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-054C	1	17	18	6	0.050	0.840	0.094	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-054D	0	18	18	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-055A	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-055B	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-055C	1	10	11	9	0.050	0.600	0.100	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-055D	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-057A	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-057B	0	16	16	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-057C	0	16	16	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-057D	0	16	16	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-059	0	17	17	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-067	0	16	16	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-079	0	17	17	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-080A	1	15	16	6	0.050	0.200	0.059	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-080B	1	15	16	6	0.050	2.00	0.172	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-080C	16	0	16	100	23.0	149	60.8	55.0	100.0% (sig -)	**Decreasing**	NA	24.0	Mar-13
U10-080D	16	0	16	100	3.10	32.1	7.72	6.40	100.0% (sig -)	**Decreasing**	NA	4.10	Mar-13
U10-081A	1	18	19	5	0.050	0.560	0.077	0.050	NA	>50% ND	NA	0.560	Mar-13
U10-081B	0	17	17	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-082A	0	13	13	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-082B	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13

TABLE A-2

Trend Analysis for Deep TCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decision

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U10-083A	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-083B	1	11	12	8	0.050	0.200	0.063	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-084A	0	14	14	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-084B	0	13	13	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-085A	0	14	14	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-085B	0	14	14	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-085C	0	13	13	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-086A	17	1	18	94	0.050	84.0	45.0	40.3	100.0% (sig +)	**Increasing**	NA	84.0	Mar-13
U10-086B	0	17	17	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-087A	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-087B	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-089A	1	15	16	6	0.050	0.200	0.059	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-089B	0	16	16	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-089C	17	0	17	100	129	750	512	530	59.8% (+)	**No Trend**	**Stable**	310	Jan-13
U10-089D	17	0	17	100	58.0	210	160	180	62.9% (+)	**No Trend**	**Stable**	58.0	Jan-13
U10-090A	2	11	13	15	0.050	0.800	0.135	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-090B	1	11	12	8	0.050	0.300	0.071	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-090C	2	11	13	15	0.050	0.200	0.073	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-090D	1	12	13	8	0.050	0.200	0.062	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-091A	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-091B	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-091C	0	15	15	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-093	19	4	23	83	0.050	12.2	3.49	2.60	88.3% (-)	**No Trend**	**Not Stable**	0.050	Mar-13
U10-094A	19	0	19	100	203	450	342	359	73.6% (+)	**No Trend**	**Stable**	240	Feb-13
U10-094B	1	17	18	6	0.050	0.200	0.058	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-095A	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-095C	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-095D	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-096	0	13	13	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-097A	3	11	14	21	0.050	0.430	0.108	0.050	NA	>50% ND	NA	0.330	Mar-13
U10-097B	1	13	14	7	0.050	0.220	0.062	0.050	NA	>50% ND	NA	0.220	Mar-13
U10-098B	0	14	14	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-098C	1	13	14	7	0.050	11.0	0.832	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-098D	0	14	14	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13

TABLE A-2

Trend Analysis for Deep TCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decision

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U10-098E	1	13	14	7	0.050	1.50	0.154	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-104	16	0	16	100	53.0	140	103	109	77.8% (-)	**No Trend**	**Stable**	91.0	Mar-13
U10-105	1	11	12	8	0.050	0.500	0.088	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-114A	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-114B	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-114C	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-115A	0	8	8	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-115B	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-115C	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-115D	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jul-10
U10-116	17	0	17	100	1.70	29.0	9.29	6.60	100.0% (sig -)	**Decreasing**	NA	1.70	Mar-13
U10-117A	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-117B	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-117C	0	8	8	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-117D	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-118A	0	7	7	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Aug-10
U10-118B	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-118C	1	8	9	11	0.050	0.200	0.067	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-118D	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-119	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-120A	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-120B	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-121	1	9	10	10	0.050	0.200	0.065	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-123A	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-123B	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-123C	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-123D	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-124A	1	12	13	8	0.050	0.430	0.079	0.050	NA	>50% ND	NA	0.430	Jan-13
U10-124B	0	13	13	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-125	1	12	13	8	0.050	0.200	0.062	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-126	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-127	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-128A	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-128B	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13

TABLE A-2

Trend Analysis for Deep TCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decision

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U10-128C	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-129A	1	9	10	10	0.050	0.300	0.075	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-129B	0	2	2	0	0.050	0.050	0.050	0.050	NA	IS	NA	0.050	Mar-13
U10-129C	0	10	10	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-129D	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-130	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-131	17	0	17	100	2.80	9.40	6.24	6.60	100.0% (sig -)	**Decreasing**	NA	2.80	Jan-13
U10-149A	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-149B	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-149C	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-149D	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-150A	0	13	13	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-150B	1	12	13	8	0.050	0.300	0.069	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-150C	12	1	13	92	0.050	347	217	240	100.0% (sig -)	**Decreasing**	NA	150	Mar-13
U10-150D	2	11	13	15	0.050	217	16.8	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-151A	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-151B	12	0	12	100	83.0	190	135	128	97.3% (sig +)	**Increasing**	NA	120	Jan-13
U10-151C	7	5	12	58	0.050	0.760	0.339	0.335	79.0% (+)	**No Trend**	**Stable**	0.760	Jan-13
U10-151D	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-159A	1	11	12	8	0.050	0.400	0.079	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-159B	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-159C	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-159D	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-160A	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-160B	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-161A	0	13	13	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-161B	1	12	13	8	0.050	0.800	0.108	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-176A	0	12	12	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-176B	0	13	13	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-176C	5	8	13	38	0.050	69.5	16.2	0.050	NA	>50% ND	NA	0.780	Feb-13
U10-176D	3	10	13	23	0.050	7.50	0.727	0.050	NA	>50% ND	NA	7.50	Feb-13
U10-178A	0	7	7	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-178B	1	6	7	14	0.050	2.00	0.329	0.050	NA	>50% ND	NA	2.00	Jan-13
U10-178C	0	7	7	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13

TABLE A-2

Trend Analysis for Deep TCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decisior

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U10-178D	0	7	7	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-179A	7	0	7	100	4.80	85.0	57.3	74.4	99.9% (sig -)	**Decreasing**	NA	4.80	Mar-13
U10-179B	7	0	7	100	110	210	170	190	97.5% (sig -)	**Decreasing**	NA	110	Mar-13
U10-179C	7	0	7	100	59.0	140	96.3	95.0	93.2% (-)	**No Trend**	**Stable**	83.0	Mar-13
U10-179D	6	0	6	100	0.190	1.30	0.688	0.690	93.2% (-)	**No Trend**	**Stable**	0.740	Feb-12
U10-180A	2	4	6	33	0.050	0.220	0.103	0.050	NA	>50% ND	NA	0.220	Mar-12
U10-180B	7	0	7	100	13.0	100	57.4	67.0	93.2% (-)	**No Trend**	**Stable**	13.0	Mar-13
U10-180C	6	0	6	100	270	510	393	399	50.0% (+)	**No Trend**	**Stable**	270	Mar-12
U10-180D	1	5	6	17	0.050	0.280	0.088	0.050	NA	>50% ND	NA	0.280	Mar-12

NOTES:

µg/L = Microgram(s) per liter.

>50% ND = greater than 50 percent nondetects.

IS = Insufficient data (less than six sample results).

Max = Maximum.

Min = Minimum.

MK = Mann Kendall.

NA = Not applicable.

Trend analysis performed using MK single-tailed test at 0.05 significance level.

For monitoring points exhibiting no trend at the 95 percent confidence level, concentrations are deemed stable if the coefficient of variation is equal to or less than 1.

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TABLE A-3

Trend Analysis for Shallow PCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decision

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U10-012	21	0	21	100	1.10	4.02	2.22	2.20	100.0% (sig -)	Decreasing	NA	1.10	Mar-13
U10-013	4	17	21	19	0.050	0.300	0.082	0.050	NA	>50% ND	NA	0.240	Mar-13
U10-014	0	21	21	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-025	1	16	17	6	0.050	0.430	0.072	0.050	NA	>50% ND	NA	0.430	Feb-13
U10-036	1	22	23	4	0.050	0.200	0.057	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-037	18	4	22	82	0.050	8.00	2.50	2.15	100.0% (sig +)	Increasing	NA	8.00	Jan-13
U10-039	0	18	18	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-040	0	18	18	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-041	0	17	17	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-043	18	5	23	78	0.050	1.60	0.768	0.610	100.0% (sig +)	Increasing	NA	1.60	Jan-13
U10-044	0	17	17	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-046	0	18	18	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-053	0	9	9	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-088A	8	3	11	73	0.050	0.720	0.319	0.200	95.7% (sig +)	Increasing	NA	0.720	Jan-13
U10-099	16	0	16	100	2.10	19.8	11.3	10.2	99.7% (sig -)	Decreasing	NA	2.10	Mar-13
U10-101	0	7	7	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U10-106	11	0	11	100	0.660	1.30	0.888	0.840	95.7% (sig -)	Decreasing	NA	0.840	Jan-13
U10-122	12	0	12	100	0.900	2.80	1.88	2.05	99.6% (sig -)	Decreasing	NA	0.900	Mar-13
U10-132	7	4	11	64	0.050	0.800	0.237	0.220	77.7% (-)	No Trend	Stable	0.220	Feb-13
U10-133	16	0	16	100	8.60	42.0	22.1	19.5	57.1% (+)	No Trend	Stable	24.0	Jan-13
U10-134	1	10	11	9	0.050	0.210	0.065	0.050	NA	>50% ND	NA	0.210	Jan-13
U10-135	0	11	11	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Jan-13
U10-142	12	0	12	100	6.70	10.0	7.72	7.35	50.0% (+)	No Trend	Stable	7.70	Jan-13
U10-143	4	4	8	50	0.050	2.00	0.460	0.175	99.3% (sig +)	Increasing	NA	2.00	Feb-13
U10-144	0	8	8	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U10-157	21	0	21	100	3.70	16.4	8.44	9.10	68.6% (+)	No Trend	Stable	6.60	Jan-13
U10-167	19	0	19	100	1.00	28.0	8.89	6.00	92.9% (+)	No Trend	Stable	8.90	Mar-13
U10-175	22	0	22	100	29.0	82.0	52.1	49.2	98.2% (sig +)	Increasing	NA	29.0	Jan-13
U9-12-001	0	26	26	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U9-12-002	0	27	27	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Mar-13
U9-12-004	8	12	20	40	0.050	0.270	0.109	0.050	NA	>50% ND	NA	0.270	Mar-13
U9-12-006	22	1	23	96	0.050	722	148	114	71.0% (-)	No Trend	Not Stable	84.0	Mar-13
U9-12-007	19	7	26	73	0.050	4.50	1.16	0.455	67.8% (-)	No Trend	Not Stable	1.20	Feb-13

TABLE A-3

Trend Analysis for Shallow PCE Plume Monitoring Locations

Operable Unit 10 – Site SS109 Record of Decisior

Well	Detect	Non-Detect	Total Samples	Detect Freq.	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	MK Result	Trend	Stability	Last Result (µg/L)	Last Result Date
U9-12-012	0	23	23	0	0.050	0.050	0.050	0.050	NA	>50% ND	NA	0.050	Feb-13
U9-12-015	14	3	17	82	0.050	0.800	0.404	0.400	97.4% (sig -)	**Decreasing**	NA	0.050	Feb-13
U9-12-016	5	13	18	28	0.050	0.200	0.083	0.050	NA	>50% ND	NA	0.050	Feb-13
U9-12-018	24	0	24	100	0.600	1.70	1.11	1.10	82.7% (+)	**No Trend**	**Stable**	0.900	Feb-13

NOTES:

µg/L = Microgram(s) per liter.

>50% ND = greater than 50 percent nondetects.

IS = Insufficient data (less than six sample results).

Max = Maximum.

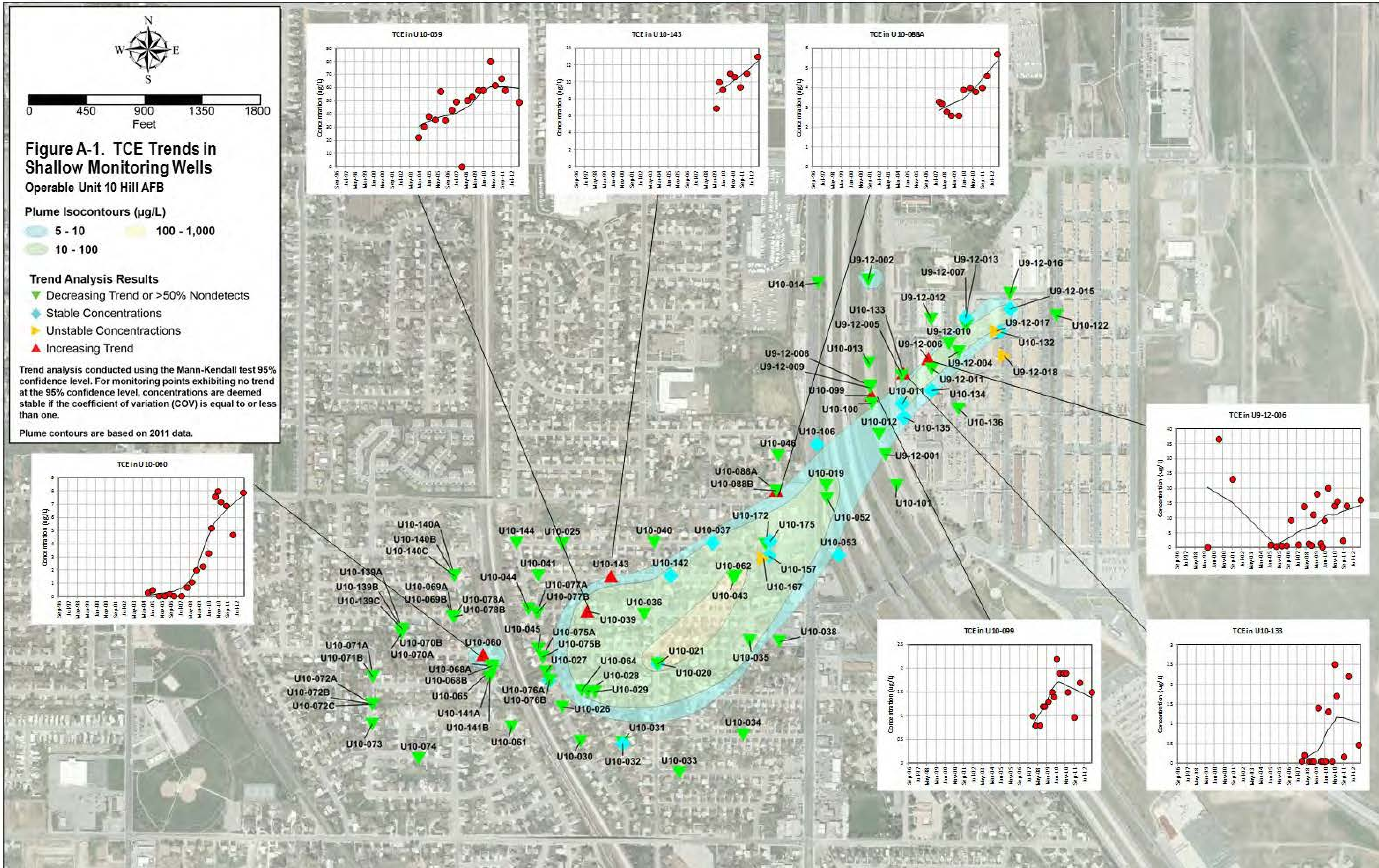
Min = Minimum.

MK = Mann Kendall.

NA = Not applicable.

Trend analysis performed using MK single-tailed test at 0.05 significance level.

For monitoring points exhibiting no trend at the 95 percent confidence level, concentrations are deemed stable if the coefficient of variation is equal to or less than 1.



N
W
E
S
0
450
900
1350
1800
Feet
Figure A-1. TCE Trends in Shallow Monitoring Wells
Operable Unit 10 Hill AFB
Plume Isocontours (µg/L)
5 - 10
10 - 100
100 - 1,000
Trend Analysis Results
Decreasing Trend or >50% Nondetects
Stable Concentrations
Unstable Concentractions
Increasing Trend
Trend analysis conducted using the Mann-Kendall test 95% confidence level. For monitoring points exhibiting no trend at the 95% confidence level, concentrations are deemed stable if the coefficient of variation (COV) is equal to or less than one.
Plume contours are based on 2011 data.
TCE in U10-039
TCE in U10-143
TCE in U10-088A
TCE in U10-060
TCE in U9-12-006
TCE in U10-099
TCE in U10-133

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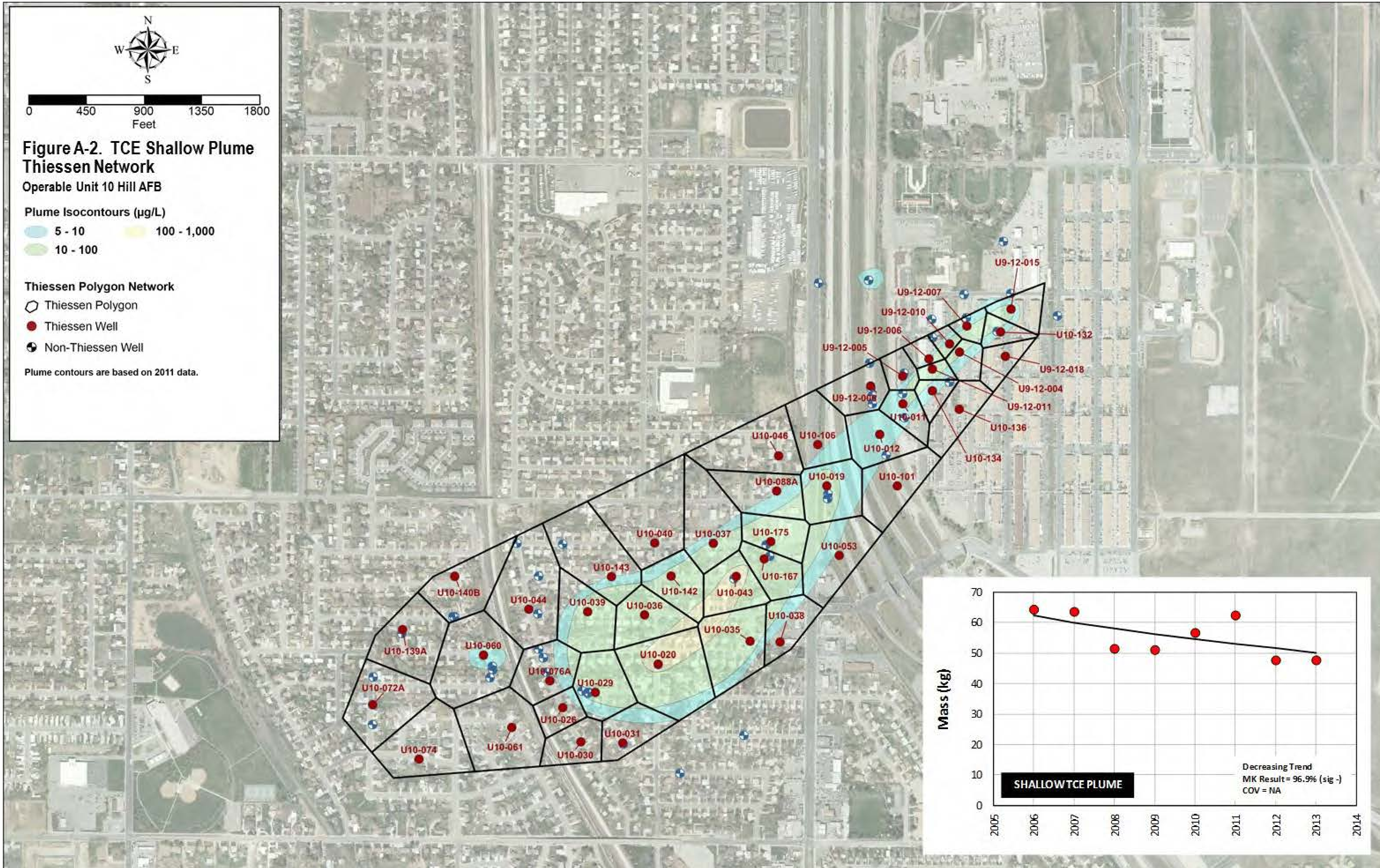

Figure A-2. TCE Shallow Plume Thiessen Network

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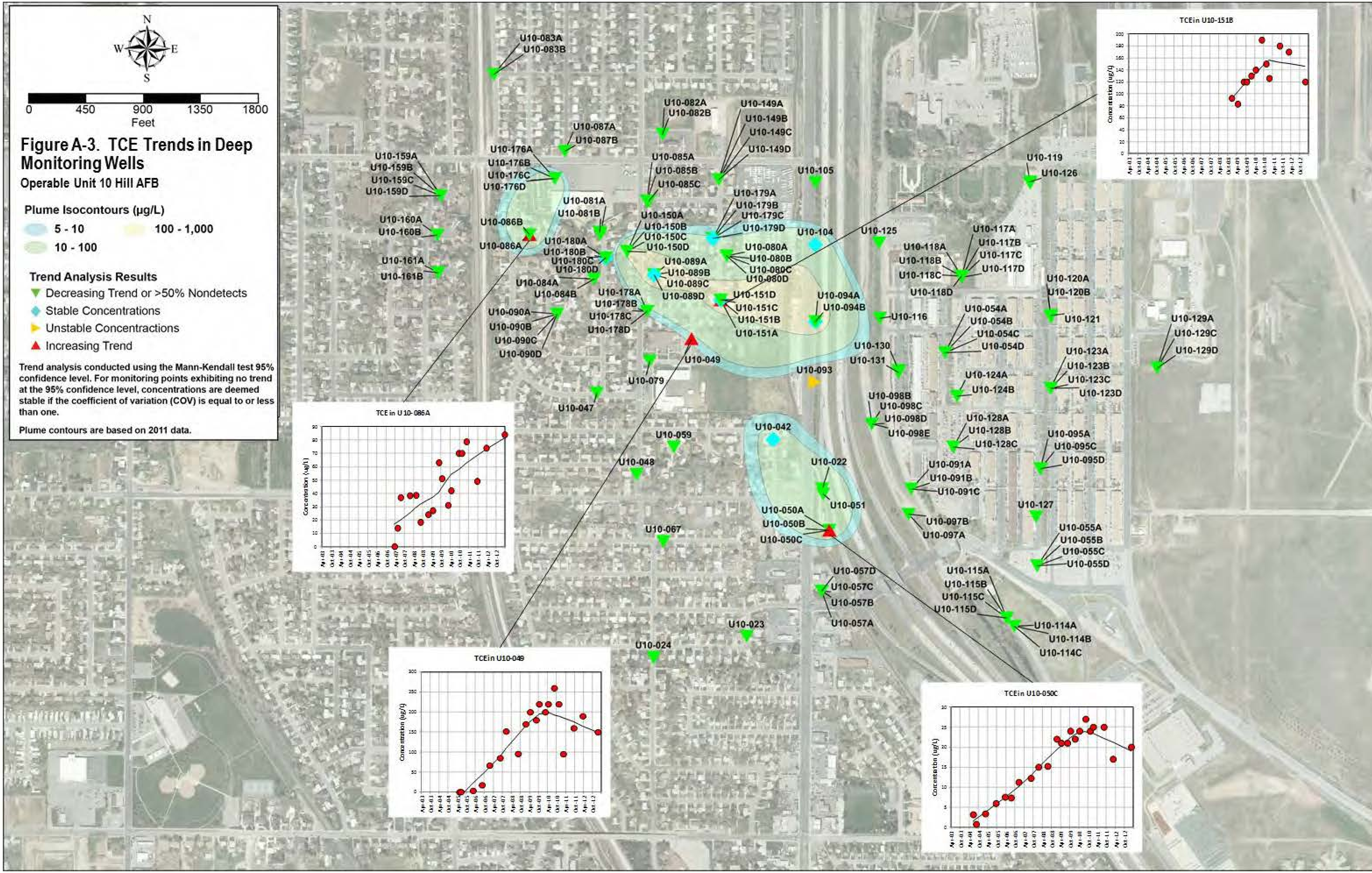

N
W
E
S
0
450
900
1350
1800
Feet
Figure A-3. TCE Trends in Deep Monitoring Wells
Operable Unit 10 Hill AFB
Plume Isocontours (µg/L)
5 - 10
10 - 100
100 - 1,000
Trend Analysis Results
Decreasing Trend or >50% Nondetects
Stable Concentrations
Unstable Concentractions
Increasing Trend
Trend analysis conducted using the Mann-Kendall test 95% confidence level. For monitoring points exhibiting no trend at the 95% confidence level, concentrations are deemed stable if the coefficient of variation (COV) is equal to or less than one.
Plume contours are based on 2011 data.
TCE in U10-151B
TCE in U10-086A
TCE in U10-049
TCE in U10-050C
U10-083A
U10-083B
U10-082A
U10-082B
U10-149A
U10-149B
U10-149C
U10-149D
U10-087A
U10-087B
U10-176A
U10-176B
U10-176C
U10-176D
U10-159A
U10-159B
U10-159C
U10-159D
U10-085A
U10-085B
U10-085C
U10-105
U10-119
U10-126
U10-179A
U10-179B
U10-179C
U10-179D
U10-081A
U10-081B
U10-086B
U10-086A
U10-160A
U10-160B
U10-150A
U10-150B
U10-150C
U10-150D
U10-104
U10-125
U10-117A
U10-117B
U10-117C
U10-117D
U10-118A
U10-118B
U10-118C
U10-118D
U10-180A
U10-180B
U10-180C
U10-180D
U10-080A
U10-080B
U10-080C
U10-080D
U10-089A
U10-089B
U10-089C
U10-089D
U10-161A
U10-161B
U10-084A
U10-084B
U10-178A
U10-178B
U10-178C
U10-178D
U10-151D
U10-151C
U10-151B
U10-151A
U10-094A
U10-094B
U10-120A
U10-120B
U10-121
U10-116
U10-054A
U10-054B
U10-054C
U10-054D
U10-129A
U10-129C
U10-129D
U10-090A
U10-090B
U10-090C
U10-090D
U10-049
U10-130
U10-131
U10-123A
U10-123B
U10-123C
U10-123D
U10-079
U10-093
U10-124A
U10-124B
U10-047
U10-098B
U10-098C
U10-098D
U10-098E
U10-128A
U10-128B
U10-128C
U10-042
U10-059
U10-095A
U10-095C
U10-095D
U10-048
U10-022
U10-091A
U10-091B
U10-091C
U10-051
U10-127
U10-050A
U10-050B
U10-050C
U10-097B
U10-097A
U10-055A
U10-055B
U10-055C
U10-055D
U10-067
U10-057D
U10-057C
U10-057B
U10-057A
U10-115A
U10-115B
U10-115C
U10-115D
U10-114A
U10-114B
U10-114C
U10-023
U10-024

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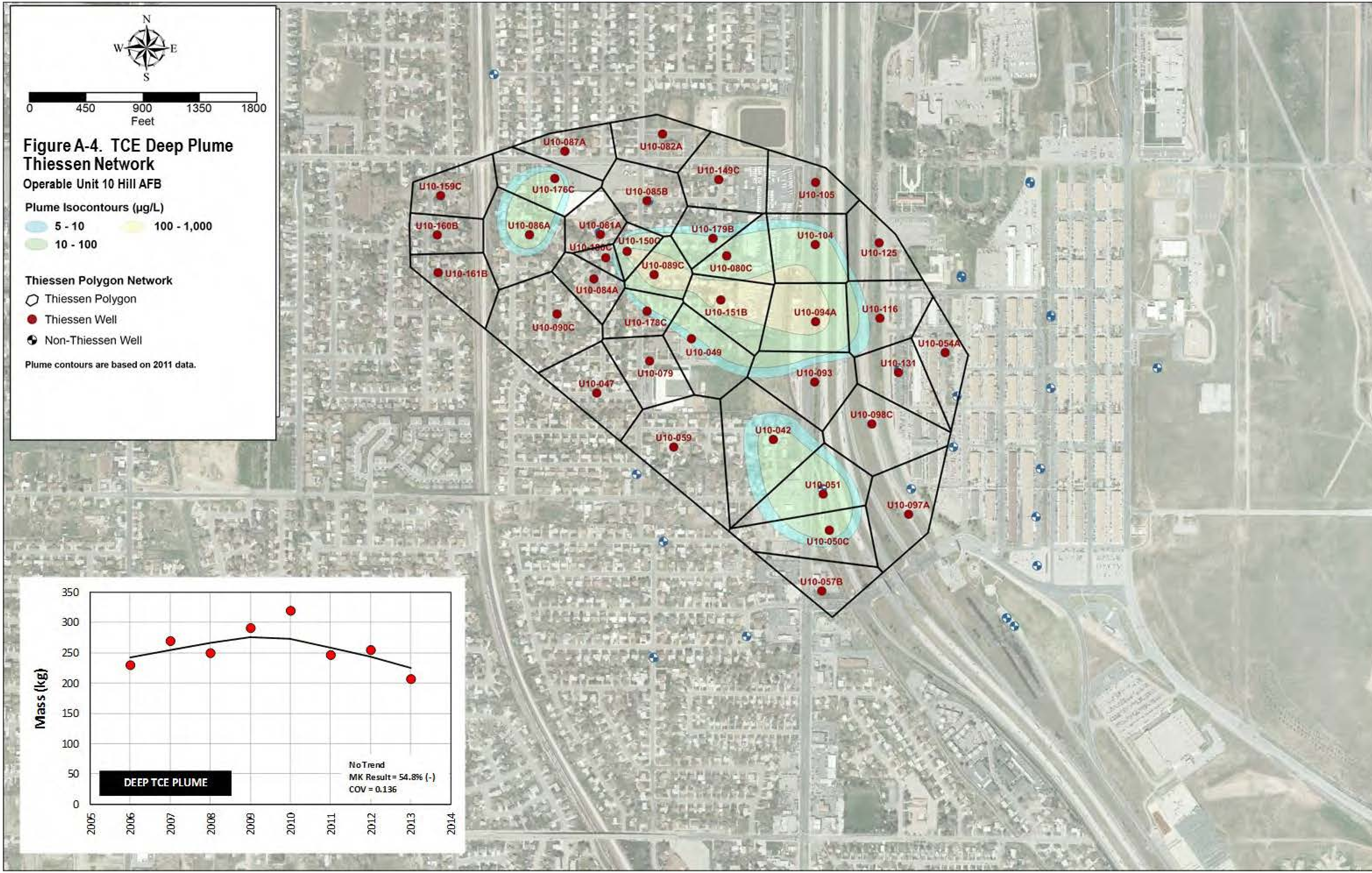

Figure A-4. TCE Deep Plume Thiessen Network
Operable Unit 10 Hill AFB

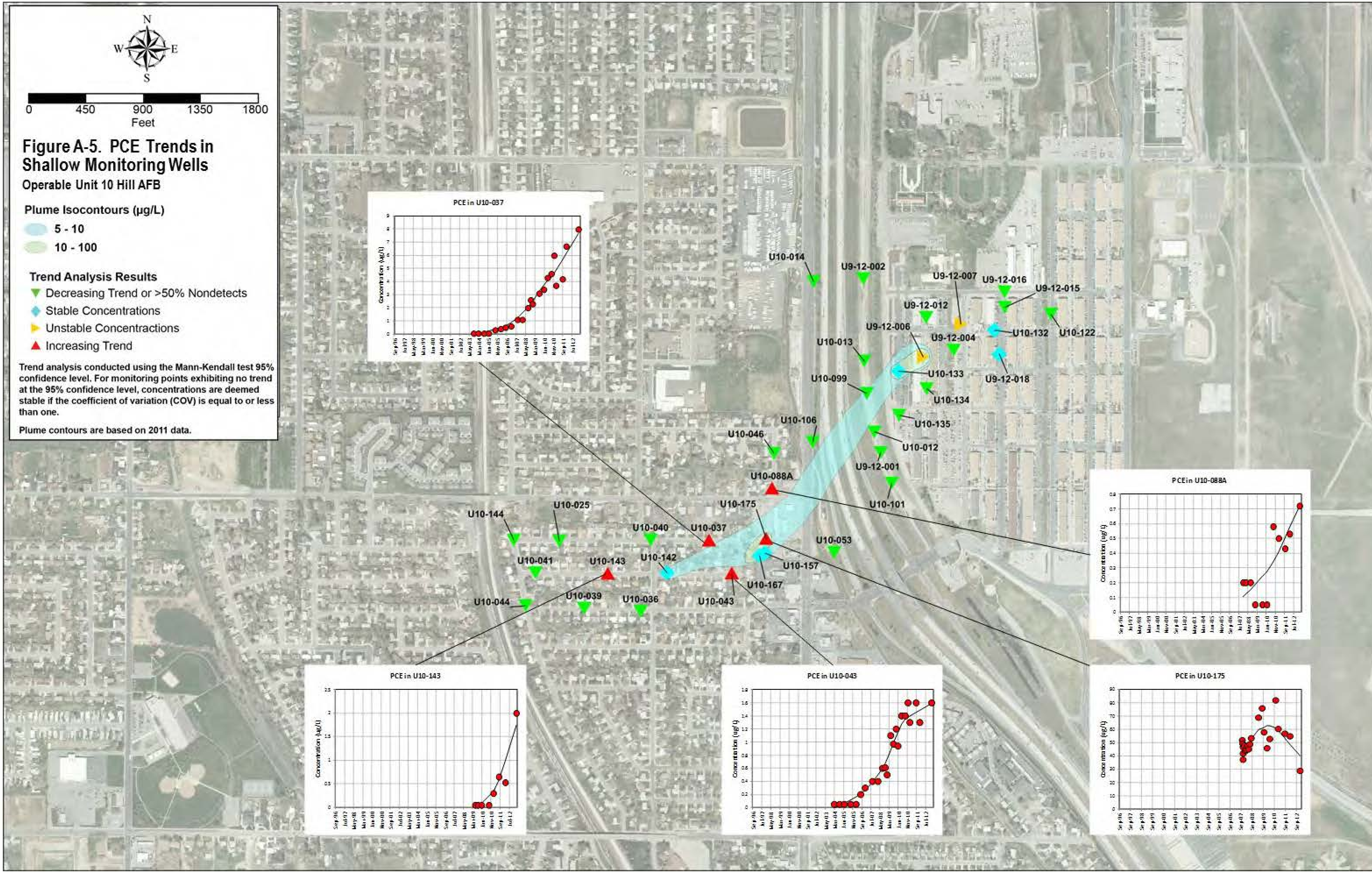

Figure A-5. PCE Trends in Shallow Monitoring Wells

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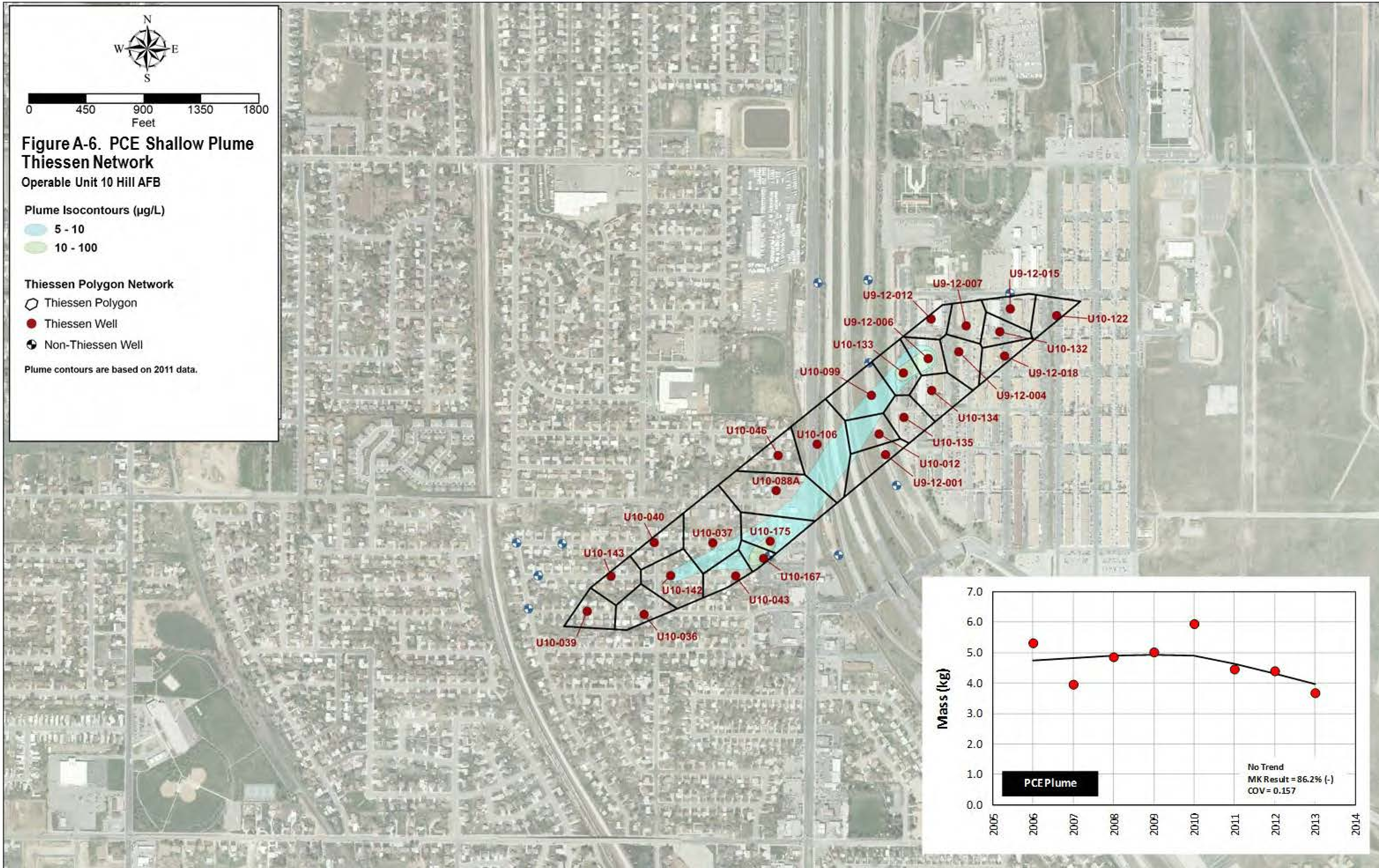

Figure A-6. PCE Shallow Plume Thiessen Network

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Appendix B
Cost Estimates

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TABLE B-1A

Alternative 6 − Present Worth Analysis for the PCE Plume Area

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

A. CAPITAL COSTS

Item No.	Cost Categories and Items	Description	Unit Cost	Quantity (#)	Units	Total Cost
1	**Hotspot Injections**					
1.1	Total Capital Cost - PCE Plume Area	Total capital cost for the 2013 Lact*Oil* injections at the PCE Plume Source Area (refer to Table B2-b for line items)	$307,765	1	LS	$307,765
1.2	Total Capital Cost - PCE Plume Area	Total capital cost for the 2018 Lact*Oil* injections at the PCE Plume Source Area (refer to Table B2-b for line items)	$54,515	1	LS	$54,515
1.3	Total Capital Cost - PCE Plume Area	Total capital cost for the 2015 Lact*Oil* injections at the PCE Mid-Plume Area (refer to Table B2-b for line items)	$97,433	1	LS	$97,433
1.4	Total Capital Cost - PCE Plume Area	Total capital cost for the 2018 Lact*Oil* injections at the PCE Mid-Plume Area (refer to Table B2-b for line items)	$69,460	1	LS	$69,460
2	**Allowances, Services, and Contingency**					
2.1	Fee	15%	$79,376	1	LS	$79,376
2.2	Professional Services	Project management, oversight, design and subcontractor requirements (Proposed Plan, ROD, Work Plan, OES, Labor)	$91,282	1	LS	$91,282
2.3	Contingency	30%	$209,949	1	LS	$209,949
	Line Item Total					**$909,780**

B. O&M COSTS

Item No.	Cost Categories and Items	Description	Unit Cost	Quantity (#)	Units	Total Cost
1	**O&M**					
1.1	Annual O&M	Monitoring Well Abandonment in 2044 (Fee Included)	$16,035	1	LS	$16,035
1.2	Annual RA-O Performance Monitoring	Annual RA-O Performance Monitoring for 2013 through 2020 (FYR, Monitoring Report, LUC Administration, Fee Included)	$259,110	1	LS	$259,110
1.3	Annual RA-O Performance Monitoring	Annual RA-O Performance Monitoring for 2021 through 2044 (FYR, Monitoring Report, LUC Administration, Fee Included)	$498,100	1	LS	$498,100
	Line Item Total					**$773,245**

C. PRESENT WORTH FOR O&M ACTIVITIES

Capital Present Worth = (Capital) x (P/F), 1.1% for 30 years $894,809

O&M Present Worth = (O&M) x (P/F), 1.1% for 30 years $674,711

D. COST SUMMARY

Cost Element	Present Value Cost ($)
Capital Costs	$895,000
O&M (through 2044)	$675,000
Total Present Worth Costs	**$1,570,000**

NOTES:

% = Percent.

F = Future Worth.

FYR = Five Year Review.

i = 2012 Real Discount Rate (30-yr) from OMB-094A (http://www.whitehouse.gov/omb/circulars_a094/a94_appx-c/).

LUC = Land Use Control.

n = Discount periods.

No. = Number.

O&M = Operations and Maintenance.

OES = Optimized Exit Strategy.

P = Present Worth.

PCE = Tetrachloroethene.

(P/F, i%, n) = 1/[(1+i)n].

PP = Proposed Plan.

RA-O = Remedial Action Operations.

ROD = Record of Decision.

WP = Work Plan.

Total Present Worth Costs have been rounded to the nearest $1,000.

Present worth costs are an estimate for planning purposes only. Actual costs will vary.

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TABLE B-1B

Alternative 6 − PCE Plume Area Capital Cost Planning-Level Estimate

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Item/Activity	Quantity	Unit	Unit Cost	Cost	Subtotals	Comments and References
PCE Hot Spot Area Injection (associated costs)						
Mob/Demob/Travel	1	LS	$5,677	$5,677		
Survey	1	LS	$3,250	$3,250		
Utility Locates	1	LS	$995	$995		Private utility locator
DPT/CPT	980	feet	$17	$16,376		Assume 35 locations to average depth of 28 feet bgs
Injection Supplies and Trailer	1	LS	$3,896	$3,896		
Lact*Oil*	6,200	pounds	$2.25	$13,950		
Treatability Study	1	LS	$250,000	$250,000		Evaluation of possible substrate and dosing scenarios
Sampling and Analysis	1	LS	$13,622	$13,622		
PCE Plume Area Source Injection (associated costs) Subtotal:					*$307,765*	
PCE Plume Hot Spot Second Injection (associated costs)						
Mob/Demob/Travel	1	LS	$5,677	$5,677		
Utility Locates	1	LS	$995	$995		Private utility locator
DPT/CPT	980	feet	$17	$16,376		Assume 35 locations to average depth of 28 feet bgs
Injection Supplies and Trailer	1	LS	$3,896	$3,896		
Lact*Oil*	6,200	pounds	$2.25	$13,950		
Sampling and Analysis	1	LS	$13,622	$13,622		
PCE Plume Area Source Second Injection (associated costs) Subtotal:					*$54,515*	
PCE Mid-Plume Area Injection (associated costs)						
Mob/Demob/Travel	1	LS	$4,569	$4,569		
Survey	1	LS	$3,250	$3,250		
Utility Locates	1	LS	$995	$995		Private utility locator
Drilling	160	feet	$67	$10,799		Assume 8 borings to average depth of 20 feet bgs
Well Installation - includes development and completion	8	each	$1,741	$13,925		Includes well development and flush mount completions
Injection Supplies and Trailer	1	LS	$15,045	$15,045		Includes costs associated with working off-Base
Lact*Oil*	5,200	pounds	$2.25	$11,700		
Sampling and Analysis	1	LS	$37,151	$37,151		
PCE Mid-Plume Area Injection (associated costs) Subtotal:					*$97,433*	
PCE Mid-Plume Area Second Injection (associated costs)						
Mob/Demob/Travel	1	LS	$4,569	$4,569		
Utility Locates	1	LS	$995	$995		Private utility locator
Injection Supplies and Trailer	1	LS	$15,045	$15,045		Includes costs associated with working off-Base
Lact*Oil*	5,200	pounds	$2.25	$11,700		
Sampling and Analysis	1	LS	$37,151	$37,151		
PCE Mid-Plume Area Second Injection (associated costs) Subtotal:					*$69,460*	
Direct Cost Subtotal:					*$529,173*	
	Fee:	15%	of	$529,173	*$79,376*	
Subcontractor Subtotal:					*$608,548*	

TABLE B-1B

Alternative 6 − PCE Plume Area Capital Cost Planning-Level Estimate

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Item/Activity	Quantity	Unit	Unit Cost	Cost	Subtotals	Comments and References
Professional Services	15%	of	$608,548	$91,282		Includes project management, construction oversight, injection performance, design, and reporting
				Professional Services Subtotal:	*$91,282*	
				Alternative 6 Subtotal:	*$699,831*	
Contingency	30%	of	$699,831	$209,949		
				Contingency Subtotal:	*$209,949*	
Alternative 6 Total Capital Cost					**$909,780**	

NOTES:

% = Percent.

bgs = Below ground surface.

DPT/CPT = Direct-push technology/cone penetrometer testing

lbs = Pounds.

LS = Lump sum.

PCE = Tetrachloroethene.

TABLE B-1C

Lact*Oil* Quantity Estimate – PCE Source Area

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Parameter	Value	Unit	Comment
Vertical Injection Interval	10.0	feet	Assume injection 30–40 feet below ground surface
Treatment Area Length	100	feet	
Treatment Area Width	100	feet	
Total Porosity	0.4		
Effective Porosity	0.2		
Total Pore Volume	299,240	gallons	
	1,132,623	liters	
Effective Pore Volume	149,620	gallons	
	566,312	liters	
Target Loading Rate	2,000	mg/L of fermentable carbon	2,000 mg/L recommended by vendor (JRW Bioremediation) for barrier application
Mass of Substrate Required	2,265,246,800	mg	As 100% fermentable carbon
	2,265	kg	
	4,995	pounds	
	80%		Percentage of Fermentable Carbon in Lact*Oil* (http://www.jrwbioremediation.com/lactoil.html)
	6,244	pounds	As Lact*Oil*
Specific Gravity of Lact*Oil*	1.05		Source = Lact*Oil* MSDS at http://www.jrwbioremediation.com/lactoil.html
Volume of Lact*Oil* Required	713	gallons	
Injection Points	40		
Volume of Lact*Oil* Required per Well	18	gallons	

NOTES:

% = Percent.

kg = Kilogram(s).

mg = Milligram(s).

mg/L = Milligram(s) per liter.

TABLE B-1D

Lact*Oil* Quantity Estimate – PCE Mid-Plume

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Parameter	Value	Unit	Comment
Vertical Injection Interval	10.0	feet	Assume injection from 20-30 feet below ground surface
Barrier Length	150	feet	
Seepage Velocity	0.465	foot/day	Assume K = 9.3 feet/day (hydraulic conductivity), I = 0.01 (gradient)
Barrier Width	55.8	feet	4–6 months groundwater travel time recommended by vendor (JRW Bioremediation); 4 months assumed for design
Total Porosity	0.4		
Effective Porosity	0.2		
Total Pore Volume	250,464	gallons	
	948,006	liters	
Effective Pore Volume	125,232	gallons	
	474,003	liters	
Target Loading Rate	2,000	mg/L of fermentable carbon	2,000 mg/L recommended by vendor (JRW Bioremediation) for barrier application
Mass of Substrate Required	1,896,011,572	mg	As 100 percent fermentable carbon
	1,896	kg	
	4,181	pounds	
	80%		Percentage of Fermentable Carbon in Lact*Oil* (http://www.jrwbioremediation.com/lactoil.html)
	5,226	pounds	As Lact*Oil*
Specific Gravity of Lact*Oil*	1.05		Source = Lact*Oil* MSDS at http://www.jrwbioremediation.com/lactoil.html
Volume of Lact*Oil* Required	596	gallons	
Injection Wells	8		Assumes 20-foot well spacing
Volume of Lact*Oil* Required per Well	80	gallons	

NOTES:

% = Percent.

kg = Kilogram(s).

mg = Milligram(s).

mg/L = Milligram(s) per liter.

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TABLE B-2A

Alternative 4 − Present Worth Analysis for the Shallow TCE Plume Area

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

A. CAPITAL COSTS

Item No.	Cost Categories and Items	Description	Unit Cost	Quantity (#)	Units	Total Cost
1	**Hotspot Injections**					
1.1	Total Capital Cost - Shallow TCE Plume Area	Total capital cost for the 2015 Lact*Oil* injections at the Shallow TCE Plume Area (refer to Table B1-b for line items)	$341,321	1	LS	$341,321
1.2	Total Capital Cost - Shallow TCE Plume Area	Total capital cost for the 2018 Lact*Oil* injections at the Shallow TCE Plume Area (refer to Table B1-b for line items)	$203,859	1	LS	$203,859
1.3	VRS installation[1]	Total capital cost for the installation of vapor removal systems at residential locations adjacent to injection locations off-Base	$2,000	12	each	$24,000
2	**Allowances, Services and Contingency**					
2.1	Fee	15%	$85,377	1	LS	$85,377
2.2	Professional Services	Project management, oversight, design and subcontractor requirements (PP, ROD, WP, OES, [illegible])	$98,184	1	LS	$98,184
2.3	Contingency	30%	$225,822	1	LS	$225,822
	Line Item Total					**$978,563**

B. O&M COSTS

Item No.	Cost Categories and Items	Description	Unit Cost	Quantity (#)	Units	Total Cost
1	**O&M**					
1.1	Annual O&M	Monitoring Well Abandonment in 2063 (Fee Included)	$24,053	1	LS	$24,053
1.2	Annual RA-O Performance Monitoring	Annual RA-O Performance Monitoring for 2013 through 2020 (FYR, Monitoring Report, LUC Administration, Fee Included)	$391,664	1	LS	$391,664
1.3	Annual RA-O Performance Monitoring	Annual RA-O Performance Monitoring for 2021 through 2063 (FYR, Monitoring Report, LUC Administration, Fee Included)	$1,180,950	1	LS	$1,180,950
1.4	Annual RA-O Performance Monitoring[1]	Indoor Air Monitoring	$12,000	7	each	$84,000
	Line Item Total					**$1,680,667**

C. PRESENT WORTH FOR O&M ACTIVITIES

Capital Present Worth = (Capital) x (P/F), 1.1% for 30 years	$946,314
O&M Present Worth = (O&M) x (P/F), 1.1% for 30 years	$1,369,685

D. COST SUMMARY

Cost Element	Present Value Cost ($)
Capital Costs	$946,000
O&M (through 2063)	$1,370,000
Total Present Worth Costs	**$2,316,000**

NOTES:

[1] Cost represent both the PCE and Shallow TCE injection areas off-Base.

% = Percent.
F = Future Worth.
FYR = Five Year Review.
i = 2012 Real Discount Rate (30-yr) from OMB-094A (http://www.whitehouse.gov/omb/circulars_a094/a94_appx-c/).
LUC = Land Use Control.
n = Discount periods.
O&M = Operations and Maintenance.
OES = Optimized Exit Strategy.
P = Present Worth.
PP = Proposed Plan.
RA-O = Remedial Actions Operations.
ROD = Record of Decision.
TCE = Trichloroethene.
WP = Work Plan
Total Present Worth Costs have been rounded to the nearest $1,000.
Present worth costs are an estimate for planning purposes only. Actual costs will vary.

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TABLE B-2B

Alternative 4 − Shallow TCE Plume Area Capital Cost Planning-Level Estimate

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Item/Activity	Quantity	Unit	Unit Cost	Cost	Subtotals	Comments and References
Shallow TCE Plume Area Hot Spot Injection (associated costs)						
Mob/Demob/Travel	1	LS	$12,613	$12,613		
Survey	1	LS	$3,250	$3,250		
Utility Locates	1	LS	$995	$995		Private utility locator
Drilling	1,200	feet	$67	$80,988		Assume 30 injection wells to average of 40 feet bgs
Well Installation - Development and Completion Included	30	each	$1,741	$52,230		Includes well development and flush mount completions
Injection Supplies and Trailer	1	LS	$15,045	$15,045		
Lact*Oil*	61,800	pounds	$2.25	$139,050		
Sampling and Analysis	1	LS	$37,151	$37,151		
Shallow TCE Plume Area Hot Spot Injection (associated costs) Subtotal:					*$341,321*	
Shallow TCE Plume Area Second Injection (associated costs)						
Mob/Demob/Travel	1	LS	$12,613	$12,613		
Injection Supplies and Trailer	1	LS	$15,045	$15,045		
Lact*Oil*	61,800	pounds	$2.25	$139,050		
Sampling and Analysis	1	LS	$37,151	$37,151		
Shallow TCE Plume Area Second Injection (associated costs) Subtotal:					*$203,859*	
VRS Installation (associated cost)						
VRS Installation	12	each	$2,000	$24,000		
VRS Installation (associated cost) Subtotal					*$24,000*	
Direct Cost Subtotal:					*$569,180*	
	Fee:	15%	of	$569,180	*$85,377*	
Subcontractor Subtotal:					*$654,557*	
Professional Services	15%	of	$654,557	$98,184		Includes project management, construction oversight, injection performance, design and reporting
Professional Services Subtotal:					*$98,184*	
Alternative 4 Subtotal:					*$752,741*	
Contingency	30%	of	$752,741	$225,822		
Contingency Subtotal:					*$225,822*	
Alternative 4 Total Capital Cost					**$978,563**	

NOTES:

% = Percent.

bgs = Below ground surface.

lbs = Pound(s).

LS = Lump sum.

TCE = Trichloroethene.

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TABLE B-2C

Lact*Oil* Quantity Estimate − Shallow TCE Plume

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

Parameter	Value	Unit	Comment
Vertical Injection Interval	24.5	feet	Assume injection from 10.55–35 feet below ground surface
Barrier Length	540	feet	
Seepage Velocity	0.625	foot/day	Assume K = 5 feet/day (hydraulic conductivity) and I = 0.025 (gradient)
Barrier Width	75	feet	4–6 months groundwater travel time recommended by vendor (JRW Bioremediation); 4 months assumed for design
Total Porosity	0.4		
Effective Porosity	0.2		
Total Pore Volume	2,963,149	gallons	
	11,215,520	liters	
Effective Pore Volume	1,481,575	gallons	
	5,607,760	liters	
Target Loading Rate	2,000	mg/L of fermentable carbon	2,000 mg/L recommended by vendor (JRW Bioremediation) for barrier application
Mass of Substrate Required (per Barrier)	22,431,040,125	mg	As 100 percent fermentable carbon
	22,431	kg	
	49,460	pounds	
	80%		Percentage of Fermentable Carbon in Lact*Oil* (http://www.jrwbioremediation.com/lactoil.html)
	61,826	pounds	As Lact*Oil*
Specific Gravity of Lact*Oil*	1.05		Source = Lact*Oil* MSDS at http://www.jrwbioremediation.com/lactoil.html
Volume of LactOil Required	7,056	gallons	
Injection Wells	27		Assumes 20-foot well spacing
Volume of Lact*Oil* Required per Well	261	gallons	

NOTES:

% = Percent.

K = Hydraulic conductivity.

kg = Kilogram(s).

mg = Milligram(s).

mg/L = Milligram(s) per liter.

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TABLE B-3

Alternative 2 – Present Worth Analysis for the Deep TCE Plume Area

Operable Unit 10 – Site SS109 (Zone 1200) Record of Decision, Hill Air Force Base, Utah

A. CAPITAL COSTS

Item No.	Cost Categories and Items	Description	Unit Cost	Quantity (#)	Units	Total Cost
1	**No Action**					
	Not applicable	Not applicable				
	Line Item Total					**$0**

B. O&M COSTS

Item No.	Cost Categories and Items	Description	Unit Cost	Quantity (#)	Units	Total Cost
1	**O&M**					
1.1	Annual O&M	Partial Monitoring Well Abandonment in 2034 (Optimization) (Fee Included)	$40,088	1	LS	$40,088
1.2	Annual O&M	Monitoring Well Abandonment in 2079 (Fee Included)	$40,088	1	LS	$40,088
1.3	Annual RA-O Performance Monitoring	Annual RA-O performance monitoring for 2013 through 2020 (FYR, Monitoring Report, LUC Administration, Fee Included)	$647,774	1	LS	$647,774
1.4	Annual RA-O Performance Monitoring	Annual RA-O performance monitoring for 2021 through 2079 (FYR, Monitoring Report, LUC Administration, Fee Included)	$2,407,950	1	LS	$2,407,950
1.5	Reporting	Reporting for 2013 through 2020 (Proposed Plan, ROD, Work Plan, OES, Labor, Fee Included)	$97,282	1	LS	$97,282
2	**Contingency**					
2.1	Contingency	10%	$323,318	1	LS	$323,318
	Line Item Total					**$3,556,500**

C. PRESENT WORTH FOR O&M ACTIVITIES

O&M Present Worth = (O&M) x (P/F), 1.1% for 30 years $2,750,477

D. COST SUMMARY

Cost Element	Present Value Cost ($)
Capital Costs	$0
O&M (through 2080)	$2,750,000
Total Present Worth Costs	**$2,750,000**

NOTES:
F = Future Worth.
FYR = Five Year Review.
i = 2012 Real Discount Rate (30-yr) from OMB-094A (http://www.whitehouse.gov/omb/circulars_a094/a94_appx-c/).
LS = Lump sum.
LUC = Land Use Control.
n = Discount periods.
O&M = Operations and Maintenance.
OES = Optimized Exit Strategy.
P = Present Worth.
(P/F, i%, n) = $1/[(1+i)^n]$.
PP = Proposed Plan.
RA-O = Remedial Action Operations.
ROD = Record of Decision.
WP = Work Plan.
Total Present Worth Costs have been rounded to the nearest $1,000.
Present worth costs are an estimate for planning purposes only. Actual costs will vary.

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Appendix C
Information Related to Public Comment Period

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FRIDAY EVENING 2/13/15

	6:00	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00
2	News	Ent	Undercover Boss (N)		Hawaii Five-0 '14-V'		Blue Bloods '14-L,V'		News	Late Show Letterman	
4	News	Inside Ed.	Charlie Brown		Shark Tank (N) 'PG-D'		(:01) 20/20 'PG' (CC)		News	Jimmy Kimmel Live	
5	News	Primetime	Constantine (N) '14-V'		Grimm (N) '14-V'		Dateline NBC (N) 'PG'		News	Tonight Show	
7	PBS NewsHour (N)		Wash	Charlie	Shakespeare		Shakespeare		Keep Up	Served?	Choice
9	TV411 'G'	Under	Journal	Mack	Health	Health	The Lady Vanishes ★★★★			Art Con	Between
11	Cyberchas	Odd	PBS NewsHour (N)		The Making of a Lady (2012) 'PG'			Holy Land		Perry Mason 'PG'	
13	Simpsons	Mod Fam	World's Funniest Fails		Glee (N) '14-D,L'		FOX13 News at Nine		Mod Fam	Seinfeld	Simpsons
14	Wheel	Jeopardy!	Jeopardy	Minute	Steve Harvey 'PG'		Friends	Friends	The Office	The Office	Raising
16	Law Order: CI		Law Order: CI		Law Order: CI		Law Order: CI		Law Order: CI		Law CI
24	Concierto				Noches con Platanito		Alarma TV	Noticiero	Jalada	Secretos	Pagado
30	Big Bang	Big Bang	Safety Not Guaranteed (2012) ★★★				News	Two Men	Two Men	Anger	Anger
A&E	The First 48 '14'		Criminal Minds		Criminal Minds		Criminal Minds		Criminal Minds '14-V'		Criminal
AMC	(5) Fool's Gold (2008) ★½			Ocean's Eleven (2001) ★★★ George Clooney. 'PG-13'					The Walking Dead		Talk Dead
ANPL	Treehouse Masters		Treehouse Masters		Treehouse Masters		American Dreamlands		Treehouse Masters		Treehouse
CNBC	Shark Tank 'PG-L'		The Celebrity Apprentice 'PG-D,L' (CC)				The Profit		The Profit		The Profit
DISC	Alaskan Bush People		Gold Rush 'PG-L'		Gold Rush 'PG-L'		Gold Rush - The Dirt		Gold Rush (N) 'PG-L'		Alaskan
DISN	Austin	Austin	(7:10) Toy Story 3 (2010) ★★★½ 'G' (CC)				Bad Hair Day (2015) 'NR' (CC)			Penn Zero	K.C.
ENC	(5:25) Starman (1984) ★★★ 'PG'			(7:25) Fun With Dick & Jane (CC)			O Brother, Where Art Thou? (2000) ★★★				Heat 'R'
ESPN	NBA Basketball		College Basketball Arizona at Washington. (N)				SportsCenter (N)		SportsCenter (N)		SportCtr
FAM	Boy/World	Boy/World	Dirty Dancing (1987, Romance) ★★★ Jennifer Grey.					Music and Lyrics (2007) ★★★ Hugh Grant.			
FX	X-Men: First Class (2011, Action) ★★★ James McAvoy.						Avatar (2009) ★★★½ Sam Worthington.				
GOLF	PGA Tour Golf			PGA Tour Golf AT&T Pebble Beach National Pro-Am, Second Round.						Golf C'tral	PGA Golf
HALL	The Lost Valentine (2011, Drama) ★★ 'PG'				Middle	Middle	The Wish List (2010, Romance) ★★★ 'PG'				Loving
HBO	(4:45) Lucky You (CC)		Edge of Tomorrow (2014) ★★★ 'PG-13'				Non-Stop (2014) ★★½ Liam Neeson. (CC)				Real Time
LIFE	Bring It! 'PG-L' (CC)		Bring It! (N) 'PG-L'		Preachers' Daughters		(:02) Bring It! 'PG-L'		(:02) Bring It! 'PG-L'		Bring It!
MAX	Queen of the Damned ★½ 'R'			(7:45) Devil's Due (2014) ★½ 'R'			(9:15) Ride Along (2014) ★★ Ice Cube. (CC)				Banshee
NIK	SpongeBob		Full House	Full House	Prince	Prince	Friends	Friends	Everybody Raymond		Raymond
ROOT	Snow	Snowboarding		Snowboarding			Snowboarding		The Dan Patrick Show		Snow
SHO	(5) Byzantium ★★★		Last Holiday (2006) ★★½ Queen Latifah.				Shameless 'MA'		The Affair 'MA-L,S'		Greetings
SPIKE	Cops	Cops	Bellator MMA Live (N) (Live)				Countdown; British		(:15) Cops	(:45) Cops	(:15) Cops
STAR	(5:55) Monsters University ★★★			(7:40) Captain America: The Winter Soldier (2014) ★★★					Million Dollar Arm (2014) ★★½		
SYFY	Night of the Demons (2009, Horror) ★★				Resident Evil: Extinction (2007, Horror) ★★				12 Monkeys '14-L,V'		Helix '14'
TBS	Big Bang	Big Bang	King of the Nerds (N)		Old School (2003) ★★½ Luke Wilson.				King of the Nerds		Cougar
TLC	What Not to Wear		Love; Lust	Love; Lust	Love; Lust	Love; Lust	Love, Lust or Run (N)		Love; Lust	Love; Lust	Say Yes
TMC	Double	(6:40) Kill Bill: Vol. 2 (2004) ★★★ Uma Thurman. 'R'					National Lampoon's Van Wilder			(10:35) Next Day Air	
TNT	(4) Bad Boys II ★★		NBA Basketball				In NBA	Smiths	Bad Boys (1995) ★★★ (CC)		
TOON	Gumball	Uncle Gra.	Teen	Steven	Gumball	Adventure	King/Hill	King/Hill	Cleveland	Cleveland	Amer. Dad
USA	Law & Order: SVU		Law & Order: SVU		Mod Fam	Mod Fam	Mod Fam	Mod Fam	Mod Fam	Mod Fam	Mod Fam

NIGHT OWL

11:30
9 Well Read
14 Community
30 TBS Cougar Town
TOON American Dad
USA Modern Family

11:31
TLC Say Yes to the Dress: Atlanta

11:35
13 Seinfeld

11:36
5 Late Night With Seth Meyers

11:37
4 Nightline

11:39
2 The Late Late Show

11:41
11 I Love Lucy

11:45
DISN Girl Meets World
SPIKE Jail

11:50
MTV Ridiculousness

midnight
9 Song of the Mountains
14 Community
30 Cougar Town
AMC Better Call Saul
ANPL Treehouse Masters
DISC Gold Rush
ESPN SportsCenter
FAM The 700 Club
HBO Real Time With Bill Maher
MAX Banshee
NICK How I Met Your Mother
TBS Movie "The Family Man"
TMC Movie "Clerks"
TNT Movie "Biker Boyz"
TOON Family Guy
USA Modern Family

12:01
A&E Criminal Minds
TLC Love, Lust or Run

12:04
LIFE Preachers' Daughters

12:05
13 'Til Death

12:07
4 Access Hollywood
11 Rick Steves' Europe

12:15
DISN Mickey Mouse
SPIKE Jail

12:25
MTV Ridiculousness

12:30
14 Dish Nation
30 How I Met Your Mother
DISN Austin & Ally
ROOT Snowboarding
TOON Family Guy
USA Sirens

12:31
TLC Love, Lust or Run

12:35
11 Smart Travels: Europe With Rudy Maxa
13 Family Guy

12:36
NICK George Lopez

12:37
4 OK! TV
5 Last Call With Carson Daly

12:39
2 Entertainment Tonight

12:45
SHOW Shameless
SPIKE Jail

1:00
7 Charlie Rose
9 Great Decisions in Foreign Policy
14 Mad About You
30 How I Met Your Mother
ANPL Treehouse Masters
DISC Alaskan Bush People
DISN Jessie
ESPN NBA Basketball
FAM Gilmore Girls
GOLF PGA Tour Golf
HBO The Jinx: The Life and Deaths of Robert Durst
MAX Banshee
MTV Broke A$$ Game Show
SYFY Movie "American Horror House"
TOON Newsreaders
USA Movie "Final Destination 3"

1:01
A&E Criminal Minds
TLC Say Yes to the Dress: Atlanta

Cops: Houston's daughter was in wreck

By KATE BRUMBACK
The Associated Press


Brown

ATLANTA — Whitney Houston's daughter was involved in a traffic accident that injured two people days before she was found face-down in a bathtub, according to a police report.

Bobbi Kristina Brown lost control of her Jeep Liberty when a tire blew out Jan. 27, crossing into oncoming traffic and hitting a vehicle. Police described "extensive damage" to both vehicles. Brown's passenger and the other car's driver were hospitalized. Officers found a nail in the Jeep's blown-out right rear tire, the incident report states.

Brown was cited in Alpharetta, Georgia, in November 2012 for failing to maintain her lane after her Chevrolet Camaro landed in a ditch. No injuries were reported.

Police had been called to Brown's townhouse in Alpharetta, where Brown has lived with her partner, Nick Gordon, several times before Brown was found unresponsive.

On Jan. 23, a security guard at their gated community called 911 reporting a fight at Brown's address. The guard said a neighbor reported people "hitting each other and swinging" outside the townhome. The guard did not describe the people involved, and no one was there when officers arrived.

Police were called to the home July 8, 2013, and Gordon told officers Brown was unresponsive after falling on the floor. Gordon described it as a seizure, but Brown told police she had no history of medical conditions and had never had a seizure. The incident report says Brown was disoriented and was taken to a hospital.

Younger brother tiptoes around bringing his older girlfriend home


Abigail Van Buren
Dear Abby

DEAR ABBY: My younger brother is 25. Three or four months ago he got out of a six-year relationship. He is now dating his former boss, a woman who is at least 15 years older than he is. As far as I know, I'm the only one he's told.

I recently asked him how the romance was going and he told me things are great. He also said he's worried about how to let the rest of our family know about this new relationship. Do you have any advice I could give him about revealing something that's sure to shock some members of our family?

— *Worried Older Brother in Kansas City, Missouri*

DEAR WORRIED: Yes. Tell him all he has to do is bring his new love interest to the next family gathering. (You can be in charge of supplying the smelling salts.)

DEAR ABBY: My husband and I completed construction on our retirement home five years ago. Even though we're not retired, we were able to move in. We are now 3 1/2 hours away from family.

We have repeatedly invited family members to enjoy our hospitality at holiday or vacation time. Some of them have taken us up on the invitation at least once. However, one of my brothers has never been here.

We have a lovely log cabin on a lake, and it can accommodate ALL family members for a gathering. Our relatives cite the long drive as the reason for staying away, while they think nothing of taking a hunting or fishing trip nearby.

I have stopped asking. My mom thinks I should continue extending invitations. Truthfully, it is a lot less work and expense to NOT host. Who's right?

— *Enough Already in Michigan*

DEAR ENOUGH: You are. By now your relatives are well aware that they are welcome. Continue to invite those who have accepted and reciprocated your hospitality, because it should be apparent that the ones who have declined are not interested. And explain that to your mother, who long ago should have stopped telling you what to do.

DEAR ABBY: Have you or any of your female readers experienced this medical phenomenon with their male partners? When I open my mouth to speak, I can literally hear my husband's ears slam shut! Repeating everything seems to be a side effect for those of us living with someone with this disease. Does anyone know of a cure?

— *Tired of Talking to Myself*

DEAR TIRED: Alas, I can't answer from personal experience because every time I open my mouth to speak, my husband rushes forward to catch the pearls of wisdom I'm spewing. However, I suspect that what you're experiencing may be a widespread phenomenon that happens when any woman suggests something her spouse doesn't want to hear. Readers, what do you think?

Contact Dear Abby at www.DearAbby.com or P.O. Box 69440, Los Angeles, CA 90069.

Your Birthday

By STELLA WILDER
Universal UClick

Born today, you are always likely to roam alone through the world. Although you are sure to enjoy lasting romantic attachments, lifelong friendships, and professional associations and partnerships that are the envy of others, there will always be a part of you that is detached, that marches to the beat of a very different drum, and who strives for things that make a difference to you and you alone in the most profound and lasting sense. You don't do things because you're supposed to; you do them, rather, because you are compelled to do them — driven by a combination of nature and stellar influence — and that combination is likely to be irresistible to you again and again throughout your lifetime.

You have a great deal of charisma, and you know how to attract attention everywhere you go. Still, you are always sure to maintain your independence and autonomy; you never let anyone gain lasting control over you. You have a keen sense of humor that helps you get through the trying times.

To see what is in store for you tomorrow, find your birthday and read the corresponding paragraph.

AQUARIUS (Jan. 20-Feb. 18) — The alternatives presented to you may not suit you entirely, but you can make the best of a situation that is not perfect.

PISCES (Feb. 19-March 20) — A new endeavor proves more difficult than expected, in a few significant ways. The help you receive just in time makes a big difference.

ARIES (March 21-April 19) — Someone is likely to step in at some point and offer you a choice that comes as a big surprise. You may not want to accept either offer.

TAURUS (April 20-May 20) — There is plenty of evidence available to support your own process of elimination, so you should have no reason merely to guess.

GEMINI (May 21-June 20) — You're nearing an important junction, and you may have to choose between two similarly attractive options.

CANCER (June 21-July 22) — You're keenly interested in the way things work — and knowing what makes other people tick will make a big difference to you.

LEO (July 23-Aug. 22) — You may not be willing to do things the way you are told to do them; rather, you're far more eager to explore your own methods.

VIRGO (Aug. 23-Sept. 22) — You aren't likely to require a great deal of hand-holding, even when you find yourself in an entirely unfamiliar situation.

LIBRA (Sept. 23-Oct. 22) — You can do much to ease another's stress at this time, but take care that you are not simply taking his or her burdens yourself.

SCORPIO (Oct. 23-Nov. 21) — You want to pursue a certain line of inquiry until you have all the answers — even if they tell you things you don't want to hear.

SAGITTARIUS (Nov. 22-Dec. 21) — It may be difficult to win another's support. First, you must attract his or her attention, which is a feat unto itself.

CAPRICORN (Dec. 22-Jan. 19) — You may not be familiar with the format you are expected to follow, but you can catch up quickly and do what is required.

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Sign-In Sheet

Public Meeting for Proposed Plan for Operable Unit 10, Hill Air Force Base, Utah
March 5, 2015 at Clearfield City Hall

Name	Name of Organization (if applicable)	Contact Number
Todd Isakson	CH2M Hill	801 864 1200
Jeremy Cox	CH2M HILL (EA Team)	385- ~~801~~ 474-8513
Jarrod Case	Hill AFB	801-777-3943
Dave Allison	UDEQ Community Inv.	801-536-4479
Sandra Bourgeois	US EPA Region 8	303-312-6666
Mo Slam	UDEQ	801-536-4178
Randy Gates	CH2M HILL	801-557-1595
JJ Allen	Clearfield City	801-525-2782

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